DISCRIMINATION PERFORMANCE IN THREE SPECIES OF MONKEYS AS A FUNCTION OF TRIAL 1 REWARD CONTINGENCY, INTERTRIAL INTERVAL, AND PRIOR TEST EXPERIENCE

By

WILLIAM N. BOYER

Bachelor of Arts
Carleton University
Ottawa, Ontario
1958

Master of Arts
The University of Toronto
Toronto, Ontario
1960

Submitted to the Faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
August, 1965

DISCRIMINATION PERFORMANCE IN THREE SPECIES OF MONKEYS

AS A FUNCTION OF TRIAL 1 REWARD CONTINGENCY,

INTERTRIAL INTERVAL, AND PRIOR

TEST EXPERIENCE

Thesis Approved:

Robert W. Scofield
Thesis Adviser

William W. Rambo

Larry L. Brown

Robert J. Marten

Thomas C. Mayberry

[illegible]
Dean of the Graduate School

ACKNOWLEDGEMENT

The author wishes to express his gratitude to Dr. Henry Cross for his advice, assistance, and encouragement in the formulation and execution of this research. I am also indebted to Dr. Robert Scofield, who assumed chairmanship of the doctoral committee after Dr. Cross, for his guidance and special help. The assistance of Dr. William Rambo, Dr. Larry Brown, Dr. Richard Rankin, and Dr. Thomas Mayberry is appreciated.

Special recognition is due Dr. Harry Harlow and Dr. Vincent Polidora of the University of Wisconsin for making available the subjects and equipment employed in a greater part of this research. Thanks are also extended to Mr. Lawrence Link who aided in programming the statistical analyses.

I also wish to express my appreciation to my wife, Bernice, for her assistance in the completion of this endeavor.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

THE PROBLEM

Background of the Problem

In the familiar two-object discrimination problem in which the noncorrection procedure is used, the organism may respond to either of two stimulus objects. Responding to one of the stimuli usually obtains a reward for S while the other response is usually nonrewarded. One of the central issues in attempting to explain discrimination learning is the relative strength of approach and avoidance tendencies to the respective positive and negative cues resulting from reward and nonreward. Harlow (1950, 1959) has attempted to clarify the effects of reward and nonreward in terms of a uniprocess theory of discrimination learning that emphasizes the inhibitory or negative reinforcement effects of nonreward. According to Harlow, animals learn "what to avoid" (avoidance responses) rather than "what to approach" (approach responses).

Two lines of evidence have been presented to support a single-factor interpretation of discrimination learning based on inhibition. The first comes from a number of experiments reporting consistently better learning following experience with an unrewarded than a rewarded stimulus object. Secondly, preliminary studies testing inhibition theory have found some evidence that there are temporal changes in object attractiveness which result from increasing the intervals of delay between successive trials of discrimination learning. Since the empirical data on temporal decay of inhibition, within the context of uniprocess theory, is relatively meager, the present research was designed to explore this problem more intensively. Similarly, more experimental evidence is needed concerning the nature of the inhibitory process in organisms having different prior test experiences, for example, completely "naive" and "test-sophisticated." The use of different species of organisms may also reveal significant facets of the inhibitory mechanism that have not yet been explored.

Hypotheses Pertinent to the Problem

The proposed area of investigation described by this research, that is, the rate of decay in time of the inhibitory process, gives rise to the following specific questions:

1. What is the influence of the positive reinforcement effect of reward on object-discrimination performance in monkeys? What is the influence of the inhibitory or negative reinforcement effects of non-reward on object-discrimination performance in monkeys?

2. What effect do various delay periods between trials have upon the rate of decay in time of the inhibitory process?

3. Is the negative reinforcement effect of nonreward associated more with "discrimination-test sophisticated" animals than naive animals?

4. Do different species of monkeys differ significantly in their ability to inhibit incorrect response tendencies associated with nonreward?

CHAPTER II

REVIEW OF THE LITERATURE

This survey of the pertinent literature may be divided into three general areas. The first will deal with Harlow's single-process theory as an explanation of object-discrimination learning. The second will pay primary attention to experiments designed to test effects of reward and nonreward on discrimination learning. The third will deal with variables applicable to the present research.

A Uniprocess Conception of Discrimination Learning

Analyzing data from a discrimination learning-set experiment, Harlow (1950) demonstrated that it was possible to identify and trace the course of a number of distinct classes of errors made by monkeys on successive trials and over a series of problems. These data were the basis for a single-factor theory of discrimination learning which emphasized inhibition or avoidance as the mechanism underlying learning. This conception of learning was later expanded and detailed by Harlow (1959). Harlow (1950, 1959) developed the hypothesis that suppression of all incompatible response tendencies or error factors defines perfect learning, and that learning is nothing more than suppression or inhibition of error factors operating within a particular problem.

Reward and Nonreward on Discrimination Learning

The formulation of the thesis that learning consists of nothing other than elimination of response tendencies inappropriate to a particular learning situation questions the notion that learning is based on the two processes of excitation and inhibition, excitation resulting from reward and inhibition resulting from nonreward. Support for a uniprocess interpretation of learning has been provided by Moss and Harlow (1947), who used the technique of training to a single stimulus on the first trial and then testing in a two-stimulus situation on the following trial. The monkey was presented on Trial 1 with a single stimulus-object covering one foodwell, the other foodwell being uncovered. For half of the problems, the Trial 1 stimulus was rewarded, and for the remaining problems it was not rewarded. Trial 2 involved presentation of the previous stimulus over one foodwell and a new stimulus over the other foodwell. The Trial 1 condition prevailed on Trial 2, that is, if the single stimulus was rewarded on Trial 1, it was rewarded on Trial 2 and the new stimulus was unrewarded. If the Trial 1 stimulus was not rewarded, it was also unrewarded on the second trial and the new stimulus was rewarded.

Employing test-sophisticated rhesus monkeys, Moss and Harlow (1947) found that discrimination performance following an unrewarded stimulus was superior to performance following a rewarded stimulus. They also reported that this difference remains constant over hundreds of problems. This phenomenon has been usually identified as the Moss-Harlow effect. Leary (1956), using test-experienced rhesus monkeys, similarly reported that if an object was presented alone and later paired with a new object, performance was optimal when the repeated object was unrewarded.

Harlow and Hicks (1957) have presented additional evidence favoring a single-process interpretation of learning. They describe an experiment in which successive single-stimulus Trial 1 responses were made correct or incorrect an equal number of times. Trial 2 was a conventional two-stimulus situation. Test-sophisticated rhesus monkeys were tested and performance was assessed by plotting the percentage of correct Trial 2 responses over a series of 90 successive problems. The results showed that performance was consistently better under Trial 1 nonrewarded than Trial 1 rewarded conditions. Harlow and Hicks also demonstrated that Trial 1 reward and Trial 1 nonreward gave rise to learning-set curves which were alike in form and paralleled each other throughout their course. The authors argued that differential curve form would result if reward and nonreward showed differential strengthening and weakening effects respectively during the course of learning. Recently, Cross and Brown (1965) found with the naive squirrel monkey that the unrewarded first-trial condition facilitated performance significantly more than the rewarded first-trial condition. Their results were interpreted as supporting evidence for the primary role of avoidance learning in discrimination performance.

Harlow (1950) using test-sophisticated rhesus monkeys and Riopelle (1955) employing naive rhesus monkeys tested the differential effects of rewarded and unrewarded initial trials utilizing the more conventional two-object Trial 1 situation. Their results are in substantial agreement with those obtained by Moss and Harlow (1947), Leary (1956), and Harlow and Hicks (1957), showing that experience with the negative cue alone resulted in fewer discrimination errors than did experience with the positive cue alone. These data more than adequately present evidence in favor of a uniprocess conception of discrimination learning based on the process of inhibition.

Influence of Test Experience

Riopelle (1953) attempted to determine whether the differential effects of rewarded and nonrewarded initial trials are altered by varying amounts of test experience. He stated "that experienced rhesus monkeys make more errors on Trial 2 after an initial success than after an initial failure, but that the reverse effect occurs with naive monkeys." Riopelle's findings were later supported by results obtained by Leary (1956). Behar (1961) also attempted to determine whether the avoidance response to nonreward would be learned in a learning-set experiment. Using relatively naive rhesus monkeys, the author observed that in the first half of the experiment, Trial 2 errors were greater following incorrect than correct Trial 1 responses. In the second half, this situation was reversed, with the frequency of avoidance of the nonrewarded stimuli exceeding 90%. Behar suggested that "the negative reinforcement effect of nonreward is absent in naive animals but is acquired in successful discrimination learning." These findings suggest that approach to rewarded stimuli and avoidance of nonrewarded stimuli are learned at different rates. It is possible that these different learning rates may also be reflected in different species of monkeys.

Empirical Findings Relevant to Decay of Inhibition

The tendency of monkeys to make fewer errors on later trials following an incorrect Trial 1 response than following a rewarded Trial 1 response, that is, the Moss-Harlow effect, has been identified by Harlow (1950) as evidence for a response-shift error factor. Harlow has referred to this phenomenon as a tendency to explore or investigate both stimuli in the discrimination problem, and has described this inappropriate tendency as a form of error. It was first observed by Harlow (1950) in a six-trial discrimination problem when he found that more errors were made on Trial 4 following 3 successive correct responses than following an initial error and two subsequent correct responses. Thus the tendency of nonreward to minimize response shift and reward to maximize it appears to be a very stable behavioral phenomenon in monkeys.

Two-factor reinforcement theorists have assumed response-shift behavior to be due to reactive inhibition. As viewed by Hull (1943), reactive inhibition was assumed to accumulate with the repetition of a reinforced response and act as a negative drive. Hull also postulated that reactive inhibition spontaneously dissipated as a simple negative function of time. One of the findings that have tended to support Hull's construct of response-produced inhibition is provided by studies which show that, given a free choice, the rat tends to avoid repeating the response made most recently in time. In a two-choice situation, this phenomenon has been referred to as an "alternation" tendency. The percentage of alternations has been found to be determined, among other things, by the time interval between trials, producing a simple negative function of time.

Heathers (1940) has shown that the avoidance of a repetition of a maze reaction in the rat decreases linearly as the time interval between responses is increased to 120 sec. Beyond this interval alternation gradually approached the chance level of 50 percent. Weitz and Wakeman (1941) also observed alternation tendency to decrease with the interval between responses up to approximately 60 sec.; after which this function began to rise. Dennis (1939), studying spontaneous alternation in rats, concluded that the phenomenon is reproducible with intervals of 60 sec. or less. Zeaman and House (1951), examining alternation behavior in a T-maze, found that the percentage of rats alternating increases linearly with the number of forced trials. Furthermore, the authors observed alternation percentage to decrease as a negatively accelerated function of the length of the delay period after a number of forced trials. Similar findings have been reported by Riley and Shapiro (1952). These authors showed the decay of reactive inhibition by introducing varying periods of delay between trials. The "alternation" tendency in a two-choice situation, or the tendency not to repeat responses, appears to be a stable phenomenon. The response-shift phenomenon in discrimination learning in monkeys may well be related to spontaneous alternation in rats.

Harlow (1959, p. 527) reported a discrimination experiment in which 10 test-sophisticated rhesus monkeys were tested on a total of 720 two-trial discrimination problems. A single stimulus object was presented on Trial 1, and it was rewarded on half of the problems and unrewarded on the others. Following a delay of 5, 10, or 20 sec., Trial 2 started with the introduction of a pair of stimuli which included the singly presented stimulus of Trial 1. Although Harlow observed no systematic differences in performance following the various delay intervals, the relative superiority of the nonrewarded over the rewarded trial remained constant at all delay intervals. Harlow further concluded that the data gave no indication of the operation of two different processes, one associated with reward and the other with nonreward. In spite of the fact that the differences in performance between the various delay intervals were not great, temporal delay produced comparable deficits under conditions of Trial 1 reward and nonreward.

Testing Harlow's theory that learning consists of inhibition of incorrect response tendencies, Lloyd and Carlson (1962) suggested that superior performance should follow a shorter intertrial interval since there should be less dissipation of inhibition in a shorter period than in a longer period. Employing a forced rewarded or nonrewarded Trial 1 followed by 5 trials with a constant intertrial interval of either 15 or 60 sec., they found no significant effect of the intertrial delay nor an effect of the first trial reward contingency. The authors considered the age of their monkeys (mean 1.7 years) as a possible explanation for their results.

Recently, Fletcher and Cross (1964) tested both relatively naive and sophisticated rhesus monkeys on a discrimination problem involving a single-stimulus, rewarded or nonrewarded, on Trial 1, followed by delays of 5 or 30 sec. which in turn, were followed by 6 subsequent trials with a constant 5-sec. intertrial interval. Fletcher and Cross reported superior Trial 2 performance following the nonrewarded Trial 1 responses by sophisticated monkeys. Subsequent intraproblem performance was about the same (90% correct). No effect of the delay variable was observed in the sophisticated Ss.

The intraproblem performance of the relatively naive Ss showed that Trial 2 performance following an incorrect Trial 1 response was superior to performance following a rewarded Trial 1 response only so long as a short intertrial interval (5 sec.) intervened between the two trials. Failure to obtain a similar result following the longer (30 sec.) delay supported an inhibition theory such as Harlow's which assumes that learning consists essentially of inhibition of incorrect response tendencies. Apparently a delay of 30 sec. was sufficiently long to allow inhibition (associated with an incorrect Trial 1 response) to dissipate to the extent that the probability of a correct Trial 2 response was not different from chance. Thus, Trial 1 reward contingency appears to influence intraproblem performance of relatively naive monkeys when the intertrial delay is sufficiently short.

Summary of the Review of the Literature

The concept of uniprocess learning based on an inhibition process has been outlined in this review. Data has been presented to support the notion that discrimination learning may be nothing more than the gradual suppression or inhibition of extraneous response tendencies. The demonstration that rhesus monkeys perform less well after an initial rewarded response than after an unrewarded response has given support to the uniprocess interpretation of discrimination learning. This phenomenon has been related to a response-shift error factor. There is also evidence that sophisticated monkeys shift more readily from an initial incorrect object choice to a correct choice than less sophisticated monkeys.

A few experiments have reported data indicating that the inhibitory or avoidance tendency associated with nonreward dissipates with time. It has been argued that inhibition associated with an incorrect response remains inhibited at the end of a short intertrial interval and increases the probability of a correct response. During a relatively longer intertrial delay, the inhibitory tendency dissipates to such a degree that the probability of a correct response is greatly reduced. A recent experiment assessing differential effects of Trial 1 reward contingency under two intertrial intervals between Trials 1 and 2 has emphasized the importance of experience in discrimination performance of monkeys. Although it has been suggested that the inhibitory tendency associated with an incorrect response dissipates more in relatively naive than test-wise monkeys, the data are too sparse for any conclusions to be drawn regarding the importance of prior test experience. To date, temporal decay of inhibition has not been tested in completely naive monkeys. Consequently, one of the main purposes of this research was to examine the nature of the effects of nonreward over time in both naive and test-sophisticated Ss.

In all previous experiments utilizing monkeys the duration of the intertrial has not been examined beyond 60 sec. Although a few experiments using durations of 30 sec. have produced dissipation of inhibition of an incorrect response, it is possible that a longer intertrial interval might result in more dissipation of inhibition to an incorrect response. Accordingly, in the present research, the range of the intertrial delays was extended to 150 sec. Furthermore, it was thought that a comparison of different species of monkeys might reveal added facets which accompany inhibition theory. At present, temporal decay functions within the context of uniprocess inhibition theory appear to have been examined only in rhesus monkeys.

The present research, a combination and extension of those described above, was designed to assess discrimination performance under the following conditions: Trial 1 reward contingency, intertrial interval between Trials 1 and 2, prior test experience of animals, and different species of monkeys.

Objectives of the Present Research

The goal of the present research has been to uncover the characteristics of the temporal course of decay of inhibition. Specifically, the following factors were investigated:

1. What effect does a single rewarded and nonrewarded object on Trial 1 have on subsequent discrimination performance in monkeys?

2. What is the effect of various intertrial intervals between the presentation of Trial 1 and Trial 2?

3. Is the temporal decay of inhibition altered by different amounts of prior test experience?

4. Do different species of monkeys differ significantly in the rate with which the inhibitory tendency dissipates with time?

CHAPTER III

PROCEDURES AND RESULTS

The present investigation was concerned with the decay of inhibition in discrimination performance and the effects of the various factors on this phenomenon.

The independent variables assessed were: (1) Trial 1 reward contingency (presentation of a single rewarded or nonrewarded object on Trial 1); (2) an intertrial interval of 10, 30, 60, 90, 120, or 150 sec. between the presentation of Trial 1 and Trial 2 only. Six additional trials were given with a constant 10 sec. intertrial interval. These variables provided the framework for three experiments to be described. Fourteen monkeys took part in the experiments. Six test-sophisticated squirrel monkeys participated in the first experiment. In the second experiment, four naive rhesus monkeys were used. Experiment III employed four naive stump-tailed monkeys.

The dependent variable consisted of the number of correct responses on Trial 2 and Trials 2 through 7 for the 24-day period.

Each experiment will be described separately with the five headings of (a) Subjects, (b) Apparatus, (c) Procedure, (d) General Design, and (e) Results.

Experiment I

Subjects

Earlier work has suggested that species may differ most significantly in the rate with which they inhibit erroneous errors (Warren and Baron, 1956; Harlow and Hicks, 1957; Warren and Kimball, 1959). One aim of this experiment was to examine the temporal decay of inhibition in a relatively primitive species of monkey.

Six adult male squirrel monkeys, *Saimiri sciurea*, from the Oklahoma State University Laboratory were employed as *S*s. They had all been previously tamed, adapted to the test room and apparatus, and used in two previous studies involving discrimination reversal learning (Cross and Brown, 1965; Cross, Fickling, Carpenter and Brown, 1964).

Apparatus

A modified version of the Wisconsin General Test Apparatus (WGTA) was employed. This apparatus consisted of a metal box, 30 X 14 X 14 in., divided into two compartments by a number of horizontal metal bars. One of the compartments housed the monkey during the testing phase. The other compartment contained the test area which was equipped with a 25-W. light source, a stimulus tray with three foodwells, and the stimulus objects to be discriminated. The stimulus tray measured 13 1/2 X 9 X 3/4 in. and the foodwells were spaced 2 1/2 in. apart and placed 2 1/2 in. from the front edge of the tray. One end of the test compartment was equipped with a one-way vision screen with a black curtain at its base to prevent the monkey from viewing the experimenter's movements. The stimulus objects comprising the problems were multidimensional objects differing from each other in many respects.

Procedure

The standard noncorrection trial procedure was employed with a currant as a reward. All problems were 7 trials in length, and 12 such problems were given each animal over each 2-day period for 24 days. Each day's testing consisted of six 7-trial problems. The set of 12 problems over each 2-day period for each S consisted of combinations of two Trial 1 reward conditions and 6 different delay intervals. The "standard" procedure of randomly presenting these problems for each S independently was employed. Each S received 12-replications of each problem.

On Trial 1 a single object was placed over a centered foodwell. Displacement of this object exposed a currant reward on half of these trials and no reward for the remaining half. This single object Trial 1 was followed by a 10, 30, 60, 90, 120, or 150 sec. delay before presentation of Trial 2 only. Trials 2 through 7 continued with a standard 10 sec. intertrial interval. On these trials the first trial object and a new object were placed over the peripheral foodwells according to a balanced random series, and the reward value of the one object was the same as its reward value on Trial 1. The interproblem interval was 60 sec.

Each trial was run by baiting the correct foodwell in the stimulus tray and covering the two foodwells with the stimulus-objects to be discriminated. The stimulus tray was pushed forward so that the stimuli were just within the animal's reach. The S was allowed to displace one stimulus object, after which the stimulus tray was pulled back for the start of the next trial. Displacement of the correct object resulted in reward for S. After an incorrect choice the stimulus tray was pulled back immediately. This noncorrection procedure was used throughout the experiment.

General Design

All Ss were exposed to all treatment conditions in the experiment. The treatments included combinations of two Trial 1 reward conditions (reward vs. nonreward) and six intertrial intervals between Trial 1 and Trial 2.

The number of correct choices made on Trial 2 and Trials 2 through 7 constituted the basic datum upon which two separate analyses of variance were performed. The first analysis was based on a 6 X 2 repeated-measures design. Since it has not been established whether the effect of the Trial 1 reward contingency is specific to the immediately following trial, whether the effect persists in a constant manner, or whether the effect interacts with subsequent trials, two analyses were appropriate. The second analysis constituted a 6 X 2 X 6 repeated-measures design.

Results of Experiment I

The first repeated-measures analysis was carried out to assess the effects of Trial 1 (reward vs. nonreward) and intertrial interval (10, 30, 60, 90, 120, or 150 sec.) between Trials 1 and 2 only. Table I depicts the summary of this analysis. The analysis yielded a significant Trial 1 reward contingency ($F = 71.01$, $df = 1/5$, $p < .001$) and a significant intertrial interval effect ($F = 3.05$, $df = 5/25$, $p < .05$).

Fig. 1 shows Trial 2 performance curves following rewarded and nonrewarded Trial 1's plotted independently for reward condition and intertrial delay. Trial 2 performance following a nonrewarded Trial 1 response was superior to performance following a Trial 1 rewarded response.

TABLE I

ANALYSIS OF VARIANCE (TRIAL 2)
SQUIRREL MONKEYS

Source	SS	df	MS	F
CF	4262.72	1	4262.72	
Total	317.29	71	4.47	
Subjects (S)	9.11	5	1.82	
Intertrial Interval (I)	43.61	5	8.72	3.05*
Reward Contingency (R)	117.56	1	117.56	71.01***
S X I	71.56	25	2.86	
S X R	8.28	5	1.66	
I X R	7.78	5	1.56	
S X I X R	59.39	25	2.38	

*p = <.05
***p = <.001

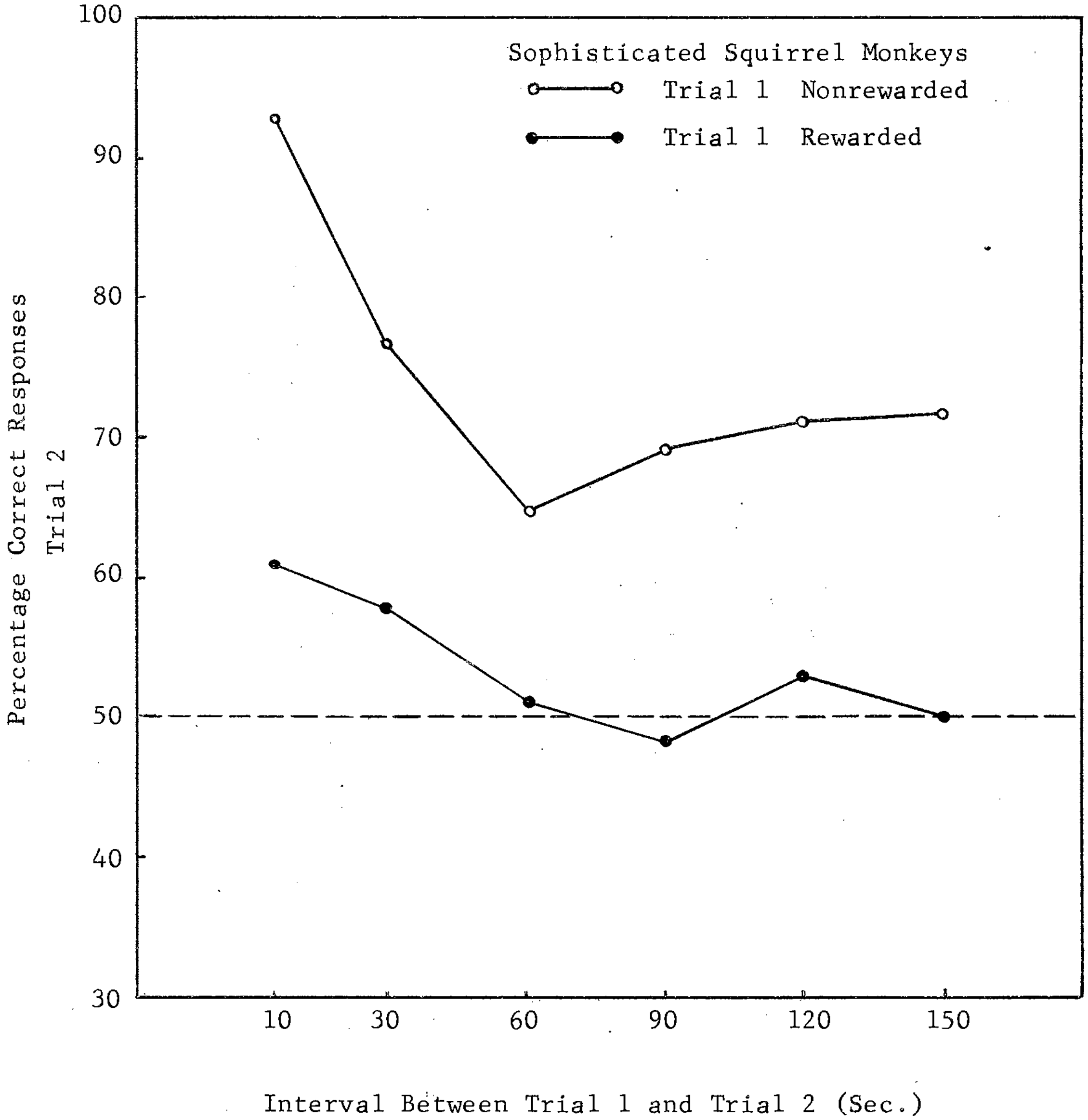

Fig. 1. Percentages of correct Trial 2 responses involving presentation of a single rewarded or nonrewarded object on Trial 1, followed by varying intervals between Trials 1 and 2.

An examination of Fig. 1 shows the relative drops in performance with increasing amounts of delay between Trials 1 and 2. The over-all significance of the delay factor suggested a more detailed analysis of performance following the nonrewarded Trial 1 response. The Newman-Keuls procedure was applied to all possible pairs of performance totals for the various intertrial delays. The results indicated that Trial 2 performance following a nonrewarded Trial 1 response with a 10 sec. delay was significantly ($p <.05$) superior to performance following a nonrewarded Trial 1 with either the 60 sec., or 150 sec. delay. Trial 2 performance following a 10 sec. delay just failed to approach significance when compared with the 90 sec. and 120 sec. delay intervals. It is possible that the relative effect of increasing the intertrial interval beyond 60 sec. produces minimal effects upon discrimination performance. Tests for these individual comparisons have been summarized in Table II.

Interproblem learning, that is, learning-set, was not the interest in this research and for this reason these data were not subjected to statistical analysis. However, they were graphed and presented for cursory consideration. Fig. 2 shows Trial 2 performance for replicated problems over 24 days. Each point on the abscissa represents 4-replications of each problem. The curves summarizing these data suggest that performance over blocks of problems was virtually the same.

A second analysis was performed to evaluate Trial 1 reward contingency, intertrial interval, and Trials (2-7). Table III reveals this analysis. An examination of Table III shows the following significant effects: Trial 1 ($F = 25.97$, $df = 1/5$, $p <.01$); intertrial interval ($F = 4.24$, $df = 5/25$, $p <.01$); Trials ($F = 14.29$, $df = 5/25$,

TABLE II

TESTS ON DIFFERENCES BETWEEN PAIRS OF TOTALS USING THE NEWMAN-KEULS PROCEDURE (TRIAL 2) SQUIRREL MONKEYS

Intertrial Interval		60	90	120	150	30	10
	Totals	47	50	51	52	56	67
60	47		3	4	5	9	20
90	50			1	2	6	17
120	51				1	5	16
150	52					4	15
30	56						11
10	57						

	2	3	4	5	6
r =	2	3	4	5	6
q.95(r,25)	2.91	3.52	3.89	4.16	4.36
q.99(r,25)	3.95	4.52	4.89	5.15	5.35
q.95(r,25) $\sqrt{\text{nMs error}}$	12.05	14.57	16.10	17.22	18.05
q.99(r,25) $\sqrt{\text{nMs error}}$	16.35	18.71	20.24	21.32	22.15

	60	90	120	150	30	10
60						*
90						
120						
150						*
30						
10						

*p = <.05

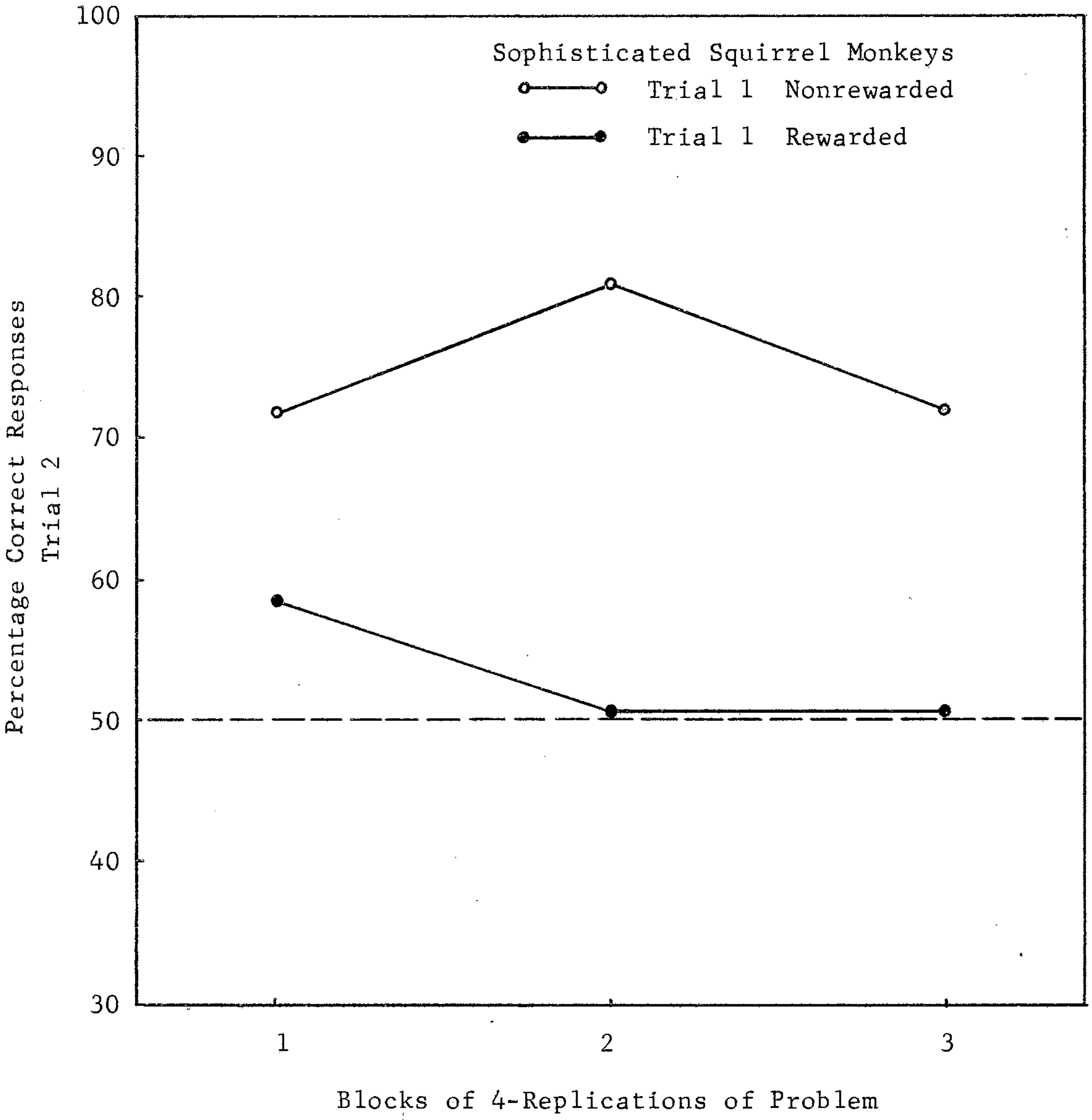

Fig. 2. Trial 2 interproblem performance following rewarded or nonrewarded single object on Trial 1 per 4-replications of each problem.

TABLE III

ANALYSIS OF VARIANCE (TRIALS 2-7)
SQUIRREL MONKEYS

Source	SS	df	MS	F
CF	32970.08	1	32970.08	
Total	1431.92	431	3.32	
Subjects (S)	20.25	5	4.05	
Intertrial Interval (I)	89.19	5	17.84	4.24**
Reward Contingency (R)	68.48	1	68.48	25.97**
Trials (T)	183.72	5	36.74	14.29***
I X R	1.80	5	.36	
I X T	68.67	25	2.75	
R X T	79.49	5	15.90	7.97***
I X R X T	46.90	25	1.88	
S X I	105.14	25	4.21	
S X R	13.19	5	2.64	
S X T	64.28	25	2.57	
S X I X R	111.87	25	4.47	
S X I X T	263.67	125	2.11	
S X R X T	49.84	25	1.99	
S X I X R X T	265.44	125	2.12	

**p = <.01
***p = <.001

$p < .001$); and Trial 1 reward contingency X Trials ($F = 7.97$, $df = 5/25$, $p < .001$).

The principal data for this analysis are found in Figs. 3 and 4. Fig. 3 reveals better performance for Trials 2-7 following a nonrewarded Trial 1 response under all delay conditions. The figure shows a general lowering in discrimination performance as a function of increased intertrial delays. Tests on differences between all possible pairs of performance totals for the delay variable were computed by the Newman-Keuls method. These values are given in Table IV. The performance following the nonrewarded Trial 1 response after a 10 sec. delay was significantly better ($p < .01$) than performance following a 60, 90, 120, or 150 sec. delay. Performance after a 30 sec. intertrial interval was significantly different ($p < .01$) from performance after a 150 sec. intertrial delay. Similarly, performance following a 90 sec. delay is significantly better ($p < .05$) than performance following a 150 sec. delay, and performance at 120 sec. is superior ($p < .05$) to performance at 150 sec. It can be seen from these comparisons (see also Fig. 3) that performance was substantially poorer when the intertrial interval was changed from 10 sec. to 30 sec. The effect of progressively increasing the interval to 120 sec. was slight, but apparently a delay of 150 sec. was sufficiently long to produce an added decrement in performance. No other differences were statistically significant for the delay factor.

The significant Trial 1 X Trials interaction effect indicates improved intraproblem performance following a rewarded or unrewarded Trial 1 response over successive trials. However, a note of caution is necessary concerning conclusions drawn from the comparison of the discrimination curves in Fig. 4. The figure shows that beyond Trial 2

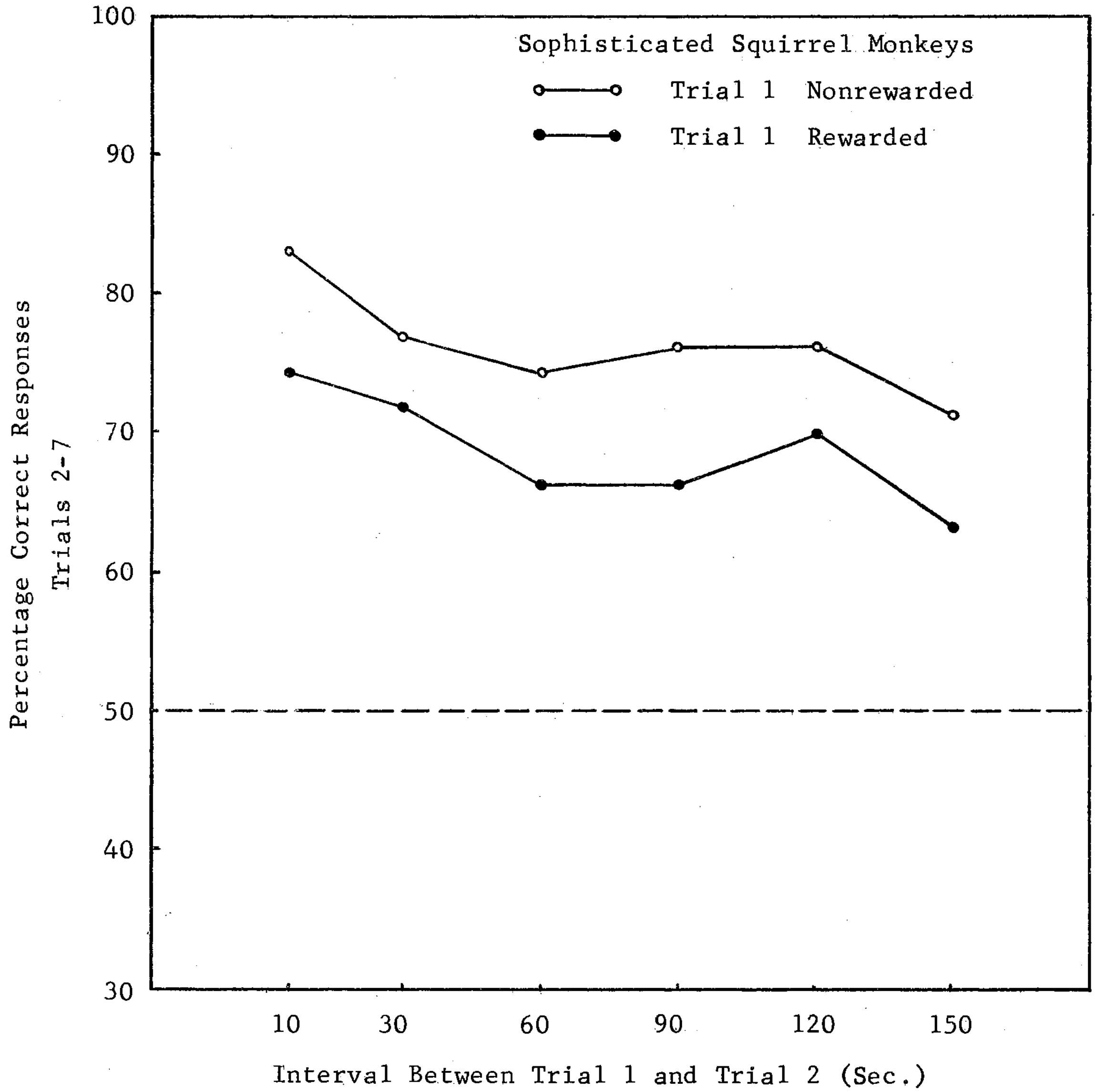

Fig. 3. Percentages of correct responses on Trials 2 through 7 involving presentation of a single rewarded or non-rewarded object on Trial 1, followed by varying intervals between Trials 1 and 2.

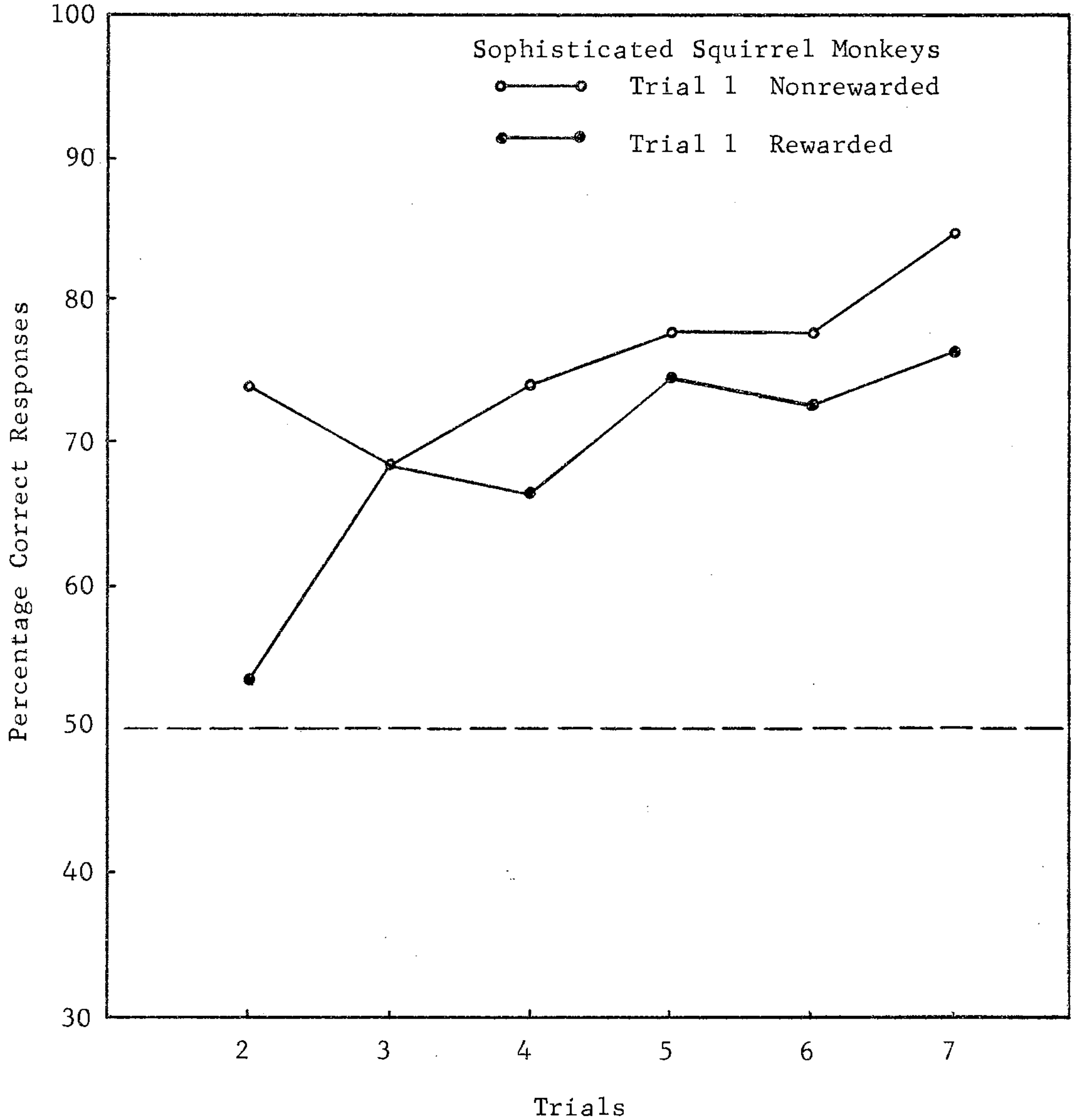

Fig. 4. Over-all intraproblem performance following rewarded or nonrewarded single objects on Trial 1.

TABLE IV

TESTS ON DIFFERENCES BETWEEN PAIRS OF TOTALS USING THE NEWMAN-KEULS PROCEDURE (TRIALS 2-7) SQUIRREL MONKEYS

Intertrial Interval		150	60	120	90	30	10
	Totals	307	321	329	330	334	350
150	307		14	22	23	27	51
60	321			8	9	13	37
120	329				1	5	29
90	330					4	28
30	334						14
10	358						

r =	2	3	4	5	6
$q_{.95}(r,25)$	2.91	3.52	3.89	4.16	4.36
$q_{.99}(r,25)$	3.95	4.52	4.89	5.15	5.35
$q_{.95}(r,25)\sqrt{nMs\ error}$	14.61	17.67	19.53	20.88	21.89
$q_{.99}(r,25)\sqrt{nMs\ error}$	19.83	22.69	24.55	25.85	26.86

	150	60	120	90	30	10
150			*	*	**	**
60						**
120						**
90						**
30						
10						

*p = <.05
**p = <.01

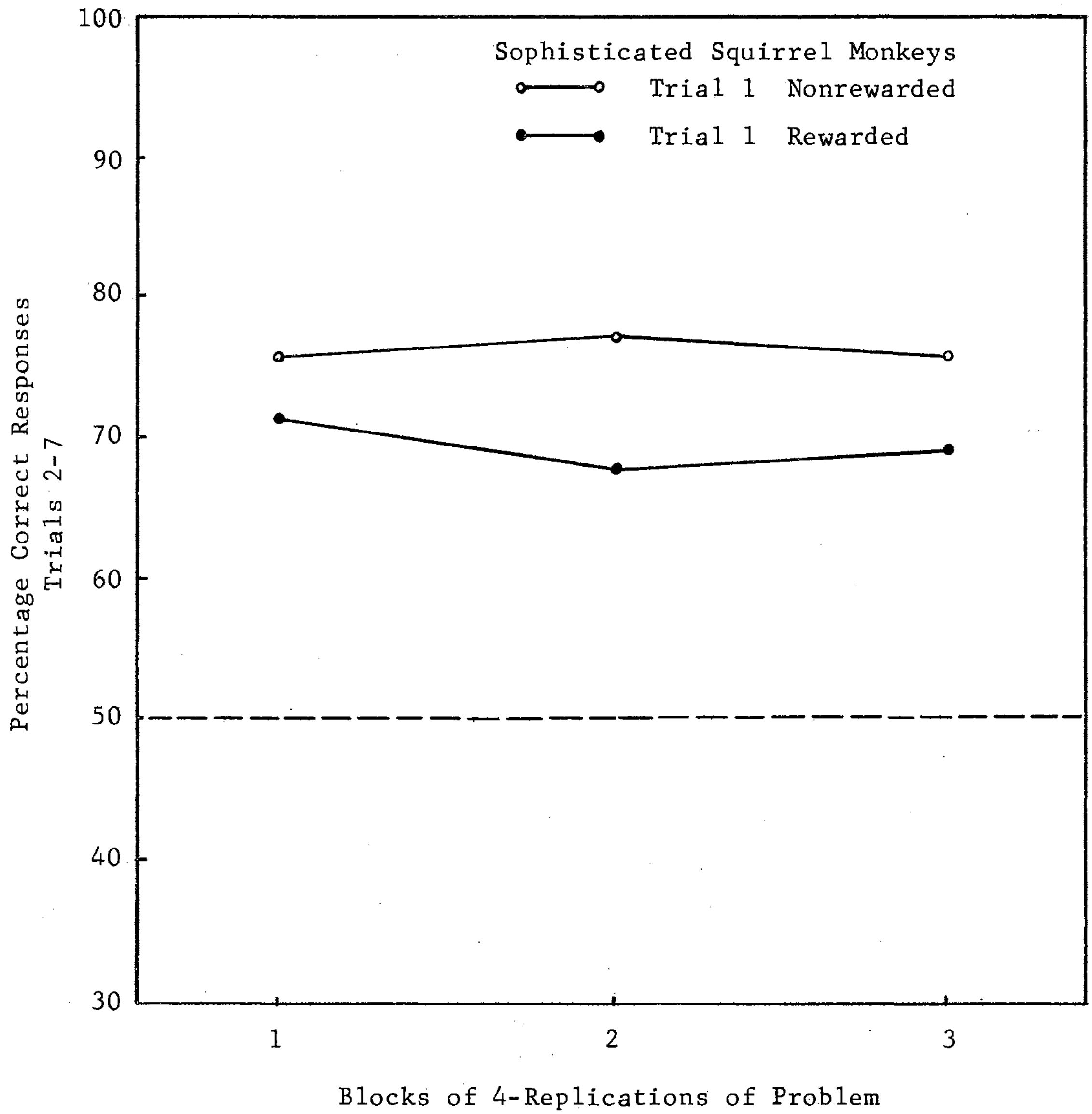

Fig. 5. Interproblem performance on Trials 2 through 7 following rewarded or nonreward single object on Trial 1 per 4-replications of each problem.

the effect of the unrewarded first trial is only slightly superior to the rewarded first trial.

Over-all interproblem performance has been presented in Fig. 5. The percentage of correct responses across blocks of problems shows negligible improvement.

Experiment II

Earlier work has almost exclusively used test-sophisticated rhesus monkeys in testing the differential effects of Trial 1 reward contingency and intertrial delays. Since there is some evidence that dissipation of inhibition may depend upon experience (Fletcher and Cross, 1964) it was decided to explore this variable by essentially replicating Exp. I employing naive rhesus monkeys.

Subjects

Four adult female rhesus monkeys, *Macaca mulatta*, served as *S*s in this experiment. The *S*s were from the colony maintained at the University of Wisconsin, Regional Primate Research Center, and had no previous test training.

Apparatus

The experiment was conducted in the standard Wisconsin General Test Apparatus (WGTA) described by Harlow (1949). The apparatus consists of a monkey's cage, an opaque forward screen which is raised and lowered between trials, a sliding stimulus tray containing three foodwells, and a one-way vision mirror through which the experimenter observes the monkey's responses.

The naive *S*s were first trained to displace a single gray block covering the center foodwell for a raisin reward. Following this training, testing was begun for all Ss. After a single-object Trial 1, all problems were run with pairs of multidimensional objects selected from the laboratory's file of objects.

Procedure

The procedure in Exp. II, was identical to that described in Exp. I. Each S received 12 problems over each 2-day period. Problems included 2 combinations of Trial 1 reward conditions (reward vs. nonreward) and six intertrial intervals between Trial 1 and 2. Each discrimination problem was presented for 7 trials using the noncorrection method. In Exp. II, a raisin reward was utilized instead of a currant reward.

General Design

The experimental design and statistical analyses for Exp. II were the same as those employed in Exp. I. Two separate analyses of variance were performed, the first on Trial 2 data, the second on Trials 2-7.

Results of Experiment II

A repeated-measures analysis of performance on Trial 2 yielded a significant Trial 1 reward condition ($F = 10.69$, $df = 1/3$, $p < .05$). The over-all effect of the intertrial interval was not significant ($F = 2.30$, $df = 5/25$, $p > .05$). Table V summarizes this analysis. Fig. 6 has portrayed the changes in performance by increasing the intertrial delay between Trials 1 and 2 following an initial rewarded or nonrewarded Trial 1 response. It may be observed that the nonrewarded first trial produced significantly more correct Trial 2 responses at all delay periods. Although the graph shows a tendency for correct Trial 2 responses to gradually diminish with increased intertrial delays, the differences were not statistically significant. Similarly, the Newman-Keuls test making comparisons among the intertrial intervals produced no significant

TABLE V

ANALYSIS OF VARIANCE (TRIAL 2)
RHESUS MONKEYS

Source	SS	df	MS	F
CF	2552.08	1	2552.08	
Total	296.08	48	6.17	
Subjects (S)	3.08	3	1.03	
Intertrial Interval (I)	15.17	5	3.03	2.30
Reward Contingency (R)	154.09	1	154.09	10.69*
S X I	19.83	15	1.32	
S X R	43.24	3	14.41	
I X R	1.66	5	.33	
S X I X R	59.01	15	3.93	

*p = <.05

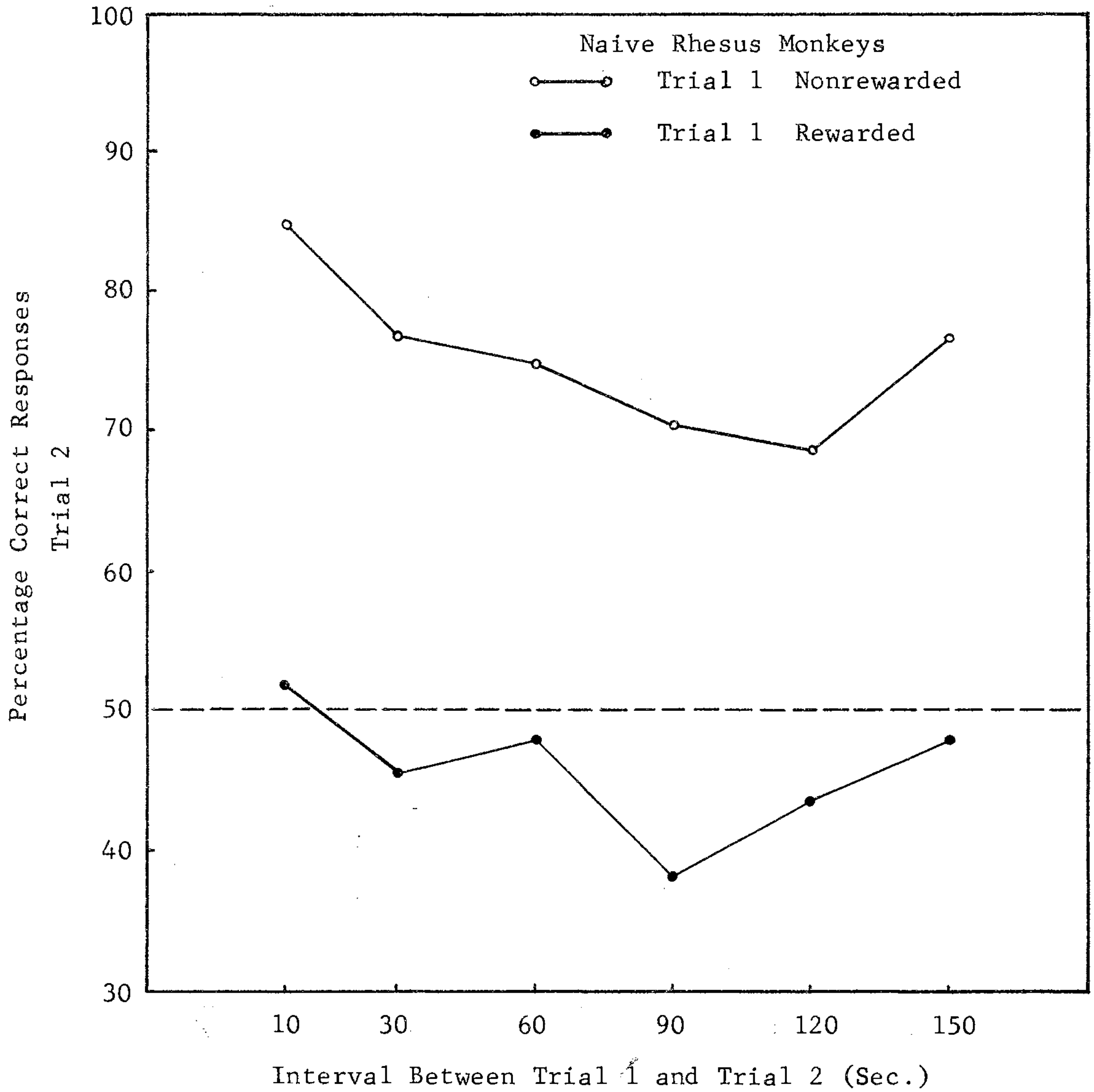

Fig. 6. Percentage of correct Trial 2 responses involving presentation of a single rewarded or nonrewarded object on Trial 1, followed by varying intervals between Trials 1 and 2.

differences (see Table VI).

The interproblem acquisition data for Trial 2 are summarized in Fig. 7. It may be seen that minor interproblem improvement occurred over blocks of problems. The effects of Trial 1 reward contingency, intertrial interval, and Trials were analyzed and the results of the analysis are presented in Table VII. The following effects were significant: Trial 1 reward condition ($F = 17.80$, $df = 1/3$, $p < .05$), Trials ($F = 13.89$, $df = 5/15$, $p < .001$), and Trial 1 X Trials ($F = 5.51$, $df = 5/15$, $p < .01$). The intertrial interval, though in the right direction, failed to reach significance ($F = 1.55$, $df = 5/15$, $p > .05$). These data are depicted in Figs. 8 and 9. Fig. 8 shows that when Trial 1 was unrewarded, monkeys displayed superior performance on Trials 2-7 at all intertrial intervals. The performance data involving a nonrewarded first trial followed by varying intertrial intervals (Fig. 8) was subjected to further analysis. Newman-Keuls tests were computed to assess significant performance differences between all pairs of intertrial intervals. As can be seen in Table VIII, the number of correct responses following a nonrewarded Trial 1 response with a 10 sec. delay was significantly greater ($p < .01$) then the number of correct choices with a 30, 60, 90, 120, or 150 sec. intertrial delay. These comparisons indicate a decrement in performance with an increase in delay from 10 to 30 sec. Under longer delays, performance was essentially the same.

Fig. 9 shows improved intraproblem performance as a function of trials following a rewarded and nonrewarded Trial 1. Superior performance following a nonrewarded Trial 1 response is evident throughout Trials 2-7. The effect of the nonrewarded Trial 1, however, seems to be largely

TABLE VI

TESTS ON DIFFERENCES BETWEEN PAIRS OF TOTAL USING THE NEWMAN-KEULS PROCEDURE (TRIAL 2) RHESUS MONKEYS

Intertrial Interval		120	90	60	30	150	10
	Totals	33	34	36	37	38	41
120	33		1	3	4	5	8
90	34			1	3	4	7
60	36				1	2	5
30	37					1	4
150	38						3
10	41						

r =	2	3	4	5	6
$q_{.95}(r,15)$	3.01	3.67	4.08	4.37	4.60
$q_{.99}(r,15)$	4.17	4.83	5.25	5.56	5.80
$q_{.95}(r,15)\sqrt{\text{nMs error}}$	6.92	8.44	9.38	10.05	10.58
$q_{.99}(r,15)\sqrt{\text{nMs error}}$	9.69	11.11	11.57	12.79	13.34

	120	90	60	30	150	10
120						
90						
60						
30						
150						
10						

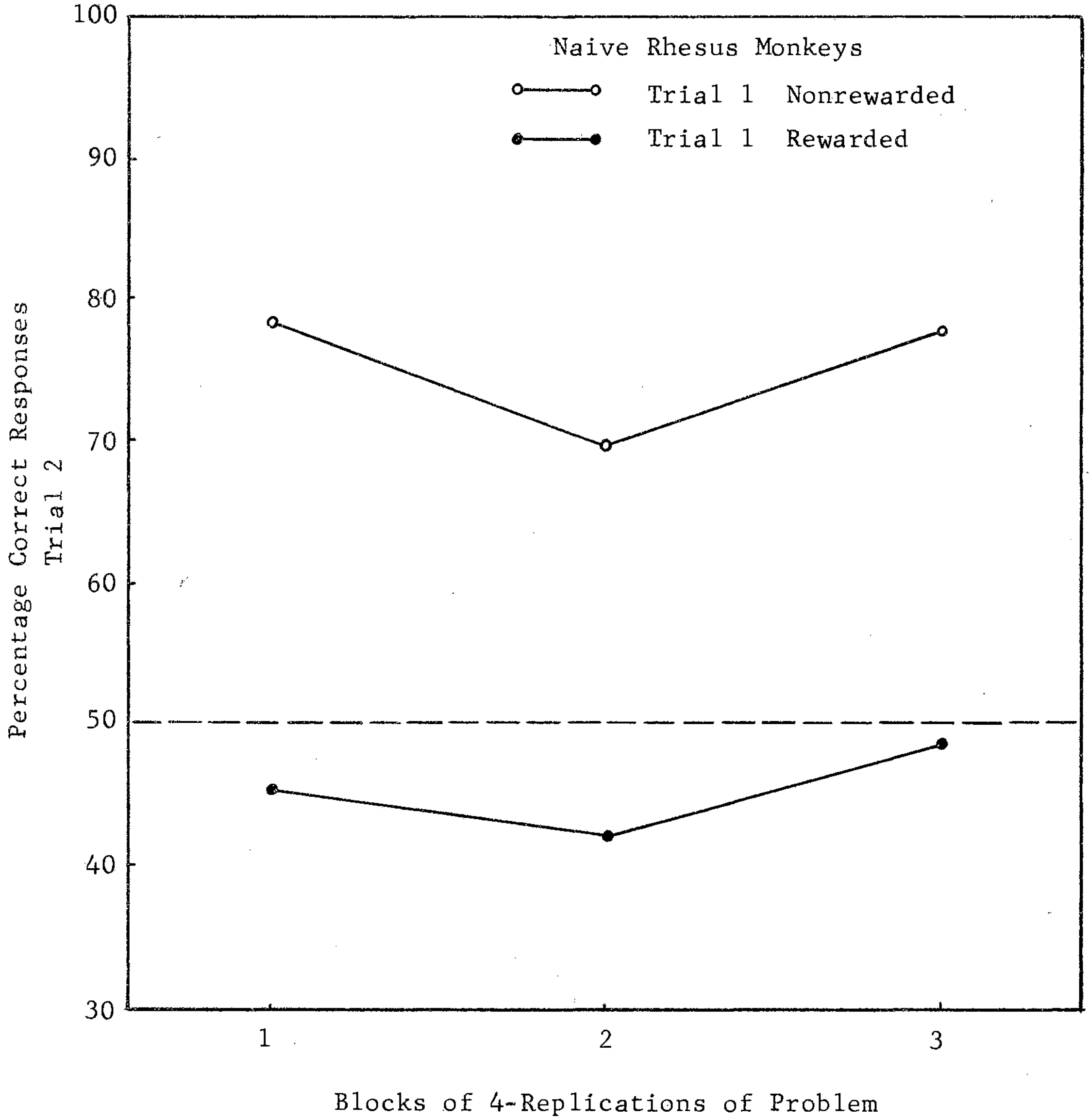

Fig. 7. Trial 2 interproblem performance following rewarded or nonrewarded single object on Trial 1 per 4-replications of each problem.

TABLE VII

ANALYSIS OF VARIANCE (TRIALS 2-7)
RHESUS MONKEYS

Source	SS	df	MS	F
CF	21562.72	1	21562.72	
Total	1063.28	287	3.70	
Subjects (S)	57.97	3	19.32	
Intertrial Interval (I)	18.07	5	3.61	
Reward Contingency (R)	95.68	1	95.68	17.80*
Trials (T)	183.65	5	36.73	13.89***
I X R	17.28	5	3.46	
I X T	53.30	25	2.13	
R X T	101.11	5	20.22	5.51**
I X R X T	36.68	25	1.47	
S X I	35.07	15	2.34	
S X R	16.13	3	5.38	
S X T	39.65	15	2.64	
S X I X R	32.75	15	2.18	
S X I X T	140.56	75	1.87	
S X R X T	55.08	15	3.67	
S X I X R X T	180.29	75	2.40	

*p = <.05
**p = <.01
***p = <.001

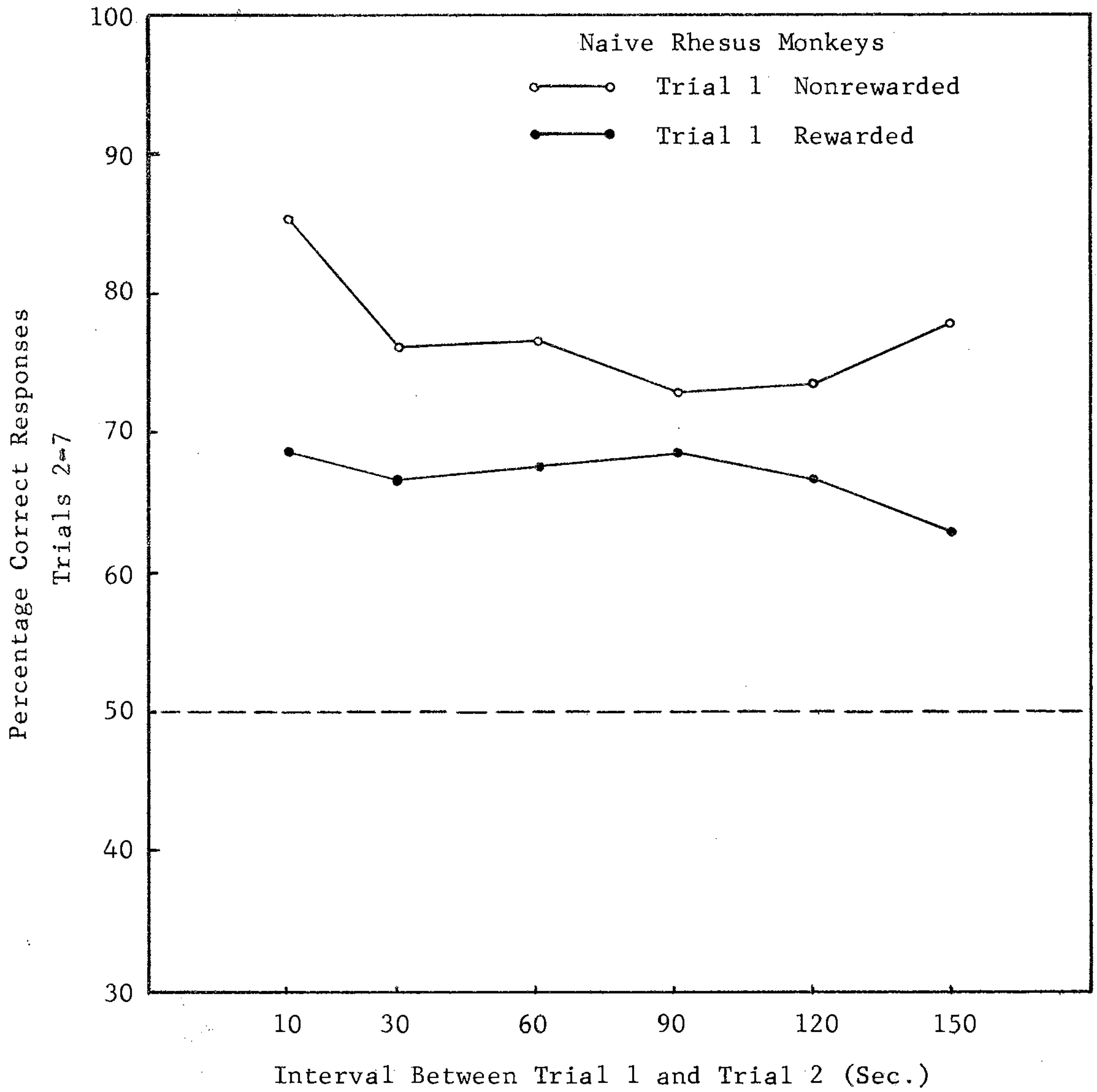

Fig. 8. Percentages of correct responses on Trials 2 through 7 involving presentation of a single rewarded or non-rewarded object on Trial 1, followed by varying intervals between Trials 1 and 2.

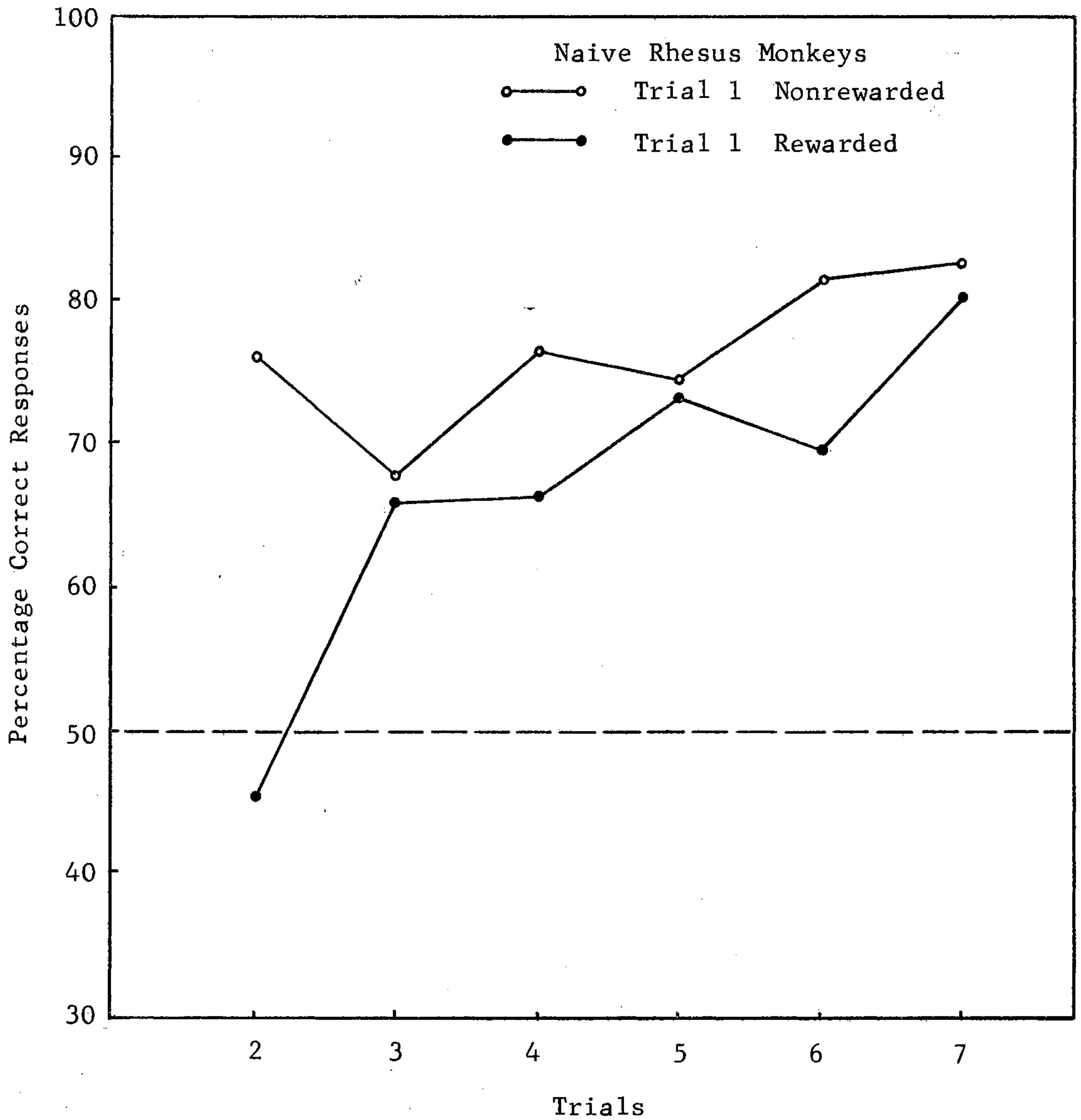

Fig. 9. Over-all intraproblem performance following rewarded or nonrewarded single objects on Trial 1.

TABLE VIII

TESTS ON DIFFERENCES BETWEEN PAIRS OF TOTALS USING THE NEWMAN-KEULS PROCEDURE (TRIALS 2-7) RHESUS MONKEYS

Intertrial Interval		90	120	30	60	150	10
	Totals	211	212	218	222	224	242
90	211		1	7	11	13	31
120	212			6	10	12	30
30	218				4	6	24
60	222					2	20
150	224						18
10	242						

r =	2	3	4	5	6
$q_{.95}(r,15)$	3.01	3.67	4.08	4.37	4.60
$q_{.99}(r,15)$	4.17	4.83	5.25	5.56	5.80
$q_{.95}(r,15)\sqrt{nMs\ error}$	9.21	11.23	12.48	13.37	14.08
$q_{.99}(r,15)\sqrt{nMs\ error}$	12.76	14.78	16.07	17.01	17.75

	90	120	30	60	150	10
90						**
120						**
30						**
60						**
150						**
10						

**p = <.01

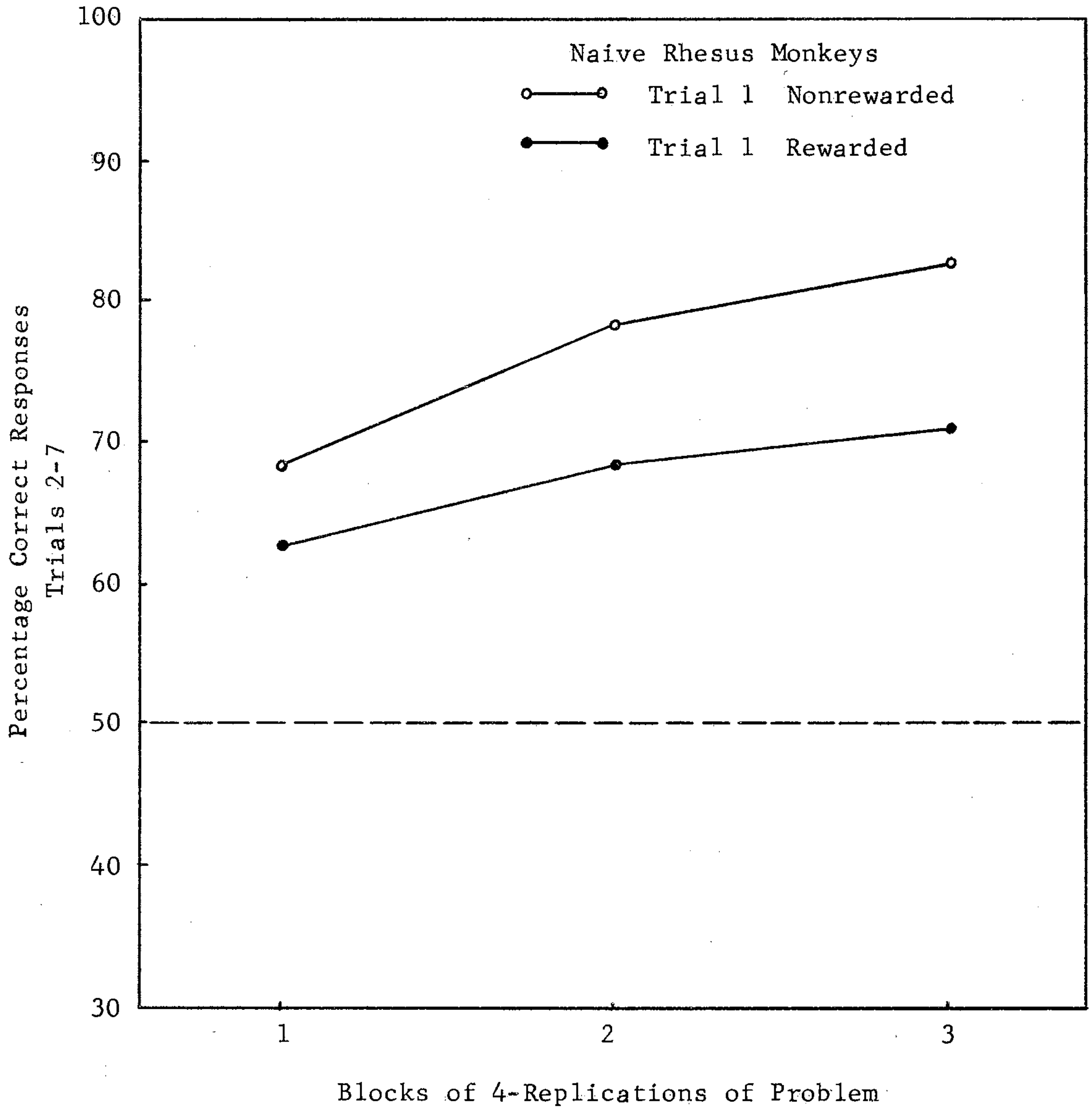

Fig. 10. Interproblem performance on Trials 2 through 7 following rewarded or nonrewarded single object on Trial 1 per 4-replications of each problem.

restricted to the immediately following Trial 2 behavior.

Interproblem performance for Trials 2-7, over-all intertrial delays, is depicted in Fig. 10. It may be noted that there is a gradual improvement in discrimination performance over blocks of replicated problems.

Experiment III

Experiment III was essentially a repetition of the first two experiments and was aimed at determining whether or not the inhibitory tendency previously reported extends to still another specie of monkey. There was also an attempt to further elaborate the relationship between previous test experience and temporal decay of inhibition in these animals by employing naive subjects.

Subjects

Four adult male stump-tailed monkeys, *Macaca speciosa*, were employed in this experiment. The *S*s were from the Wisconsin Regional Primate Research Center and were experimentally naive at the start of the experiment. They were tamed, accustomed to the test situation, and trained to displace a gray block covering a center foodwell for a raisin reward prior to testing.

Apparatus

Adaptation and testing was conducted in the WGTA (Harlow, 1949) previously described. Identical apparatus and stimulus objects were used in Exp.'s II and III.

Procedure

The experimental procedure for Exp. III closely followed that outlined for Exp. I. Twelve successive discrimination problems, seven trials per problem, were administered over each two-day period for a total of 24 days. Each S received 12-replications of each problem.

General Design

Two separate analyses were carried out in Exp. III as was the case for Exps. I and II. The differential effect of Trial 1 reward contingency, and intertrial interval on Trial 2 performance, constituted the first analysis. Trial 1 reward contingency, intertrial interval, and Trials provided data for the second analysis.

Results of Experiment III

In Table IX, the analysis of variance is given for Trial 2 data. The results indicate that the Trial 1 reward contingency was highly significant ($F = 359.02$, $df = 1/3$, $p < .001$). The nature of the effect of Trial 1 reward treatment is illustrated in Fig. 11, in which percentage of correct Trial 2 responses is plotted over the entire range of intertrial intervals. Fig. 11 shows that the nonrewarded first response resulted in significantly superior performance over all intertrial intervals. The delay factor lacked over-all statistical significance ($F = .35$, $df = 5/15$, $p > .05$). Further analysis was carried out with the Newman-Keuls test to determine differences in performance between all pairs of intertrial intervals. It can be seen in Table X that no comparison produced a significant difference.

Fig. 12 illustrates consistent improvement in the rate with which the monkeys solved discrimination problems over blocks of replications. Again, better performance is obtained when the initial stimulus object is nonrewarded.

Table XI presents a summary of the second analysis for Exp. III. Using a repeated-measures analysis to evaluate differential Trial 1 reward conditions, intertrial interval, and Trials, the following effects

TABLE IX

ANALYSIS OF VARIANCE (TRIAL 2)
STUMP-TAILED MONKEYS

Source	SS	df	MS	F
CF	2494.08	1	2494.08	
Total	273.92	48	5.71	
Subjects (S)	4.08	3	1.36	
Intertrial Interval (I)	14.42	5	2.88	
Reward Contingency (R)	168.75	1	168.75	359.04***
S X I	4.25	5	.85	
S X R	45.42	15	3.03	
I X R	1.42	3	.47	
S X I X R	35.58	15	2.37	

***p = <.001

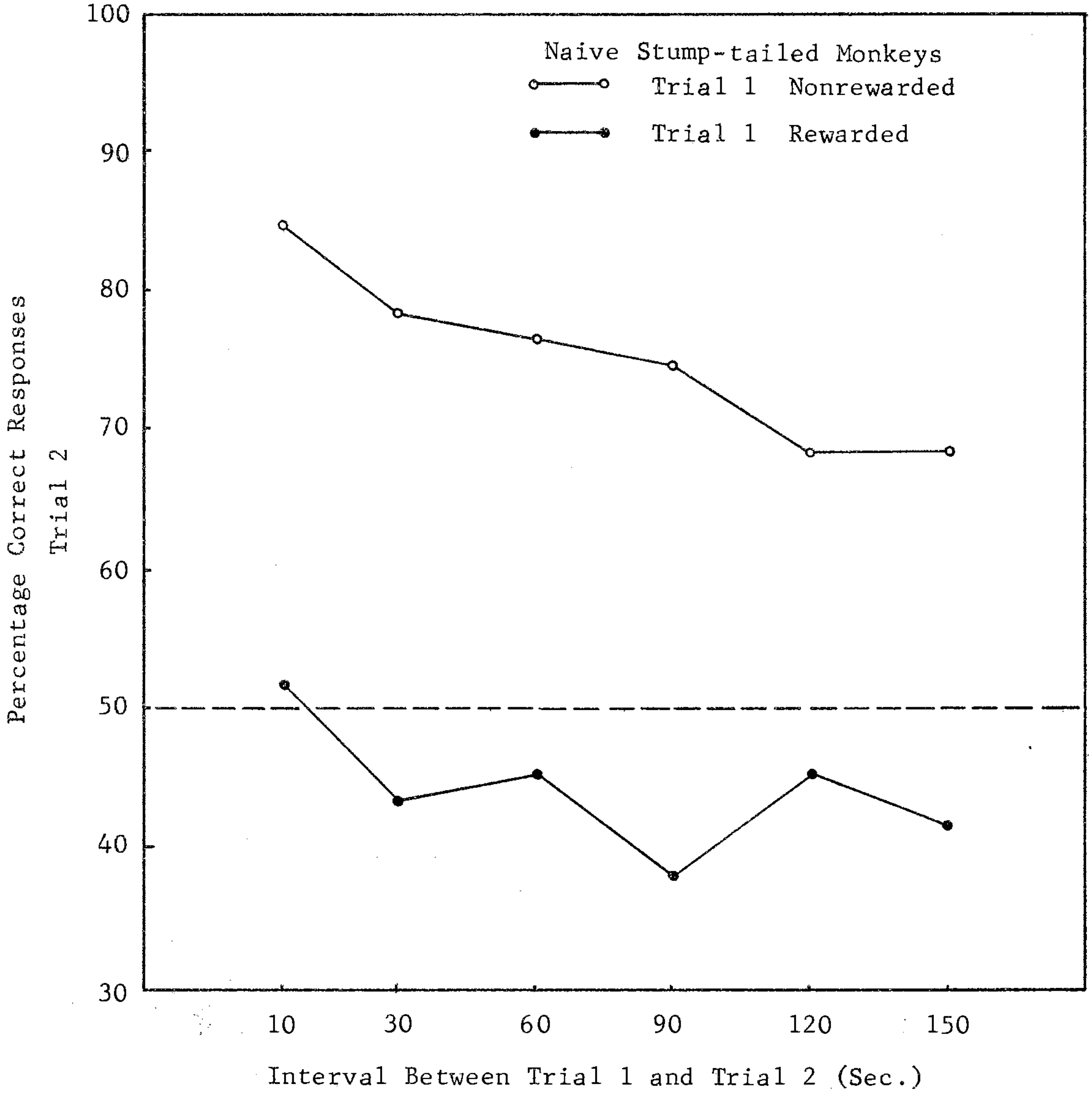

Fig. 11. Percentages of correct Trial 2 responses involving presentation of a single rewarded or nonrewarded object on Trial 1, followed by varying intervals between Trials 1 and 2.

TABLE X

TESTS ON DIFFERENCES BETWEEN PAIRS OF TOTALS USING THE NEWMAN-KEULS PROCEDURE (TRIAL 2) STUMP-TAILED MONKEYS

Intertrial Interval		150	120	90	60	30	10
	Totals	33	33	36	37	38	41
150	33		0	3	4	5	8
120	33			3	4	5	8
90	36				1	2	5
60	37					1	4
30	38						3
10	41						

	2	3	4	5	6
r =	2	3	4	5	6
$q_{.95}(r,15)$	3.01	3.67	4.08	4.37	4.60
$q_{.99}(r,15)$	4.17	4.83	5.25	5.56	5.80
$q_{.95}(r,15)\sqrt{nMs\ error}$	10.47	12.77	14.20	15.21	16.01
$q_{.99}(r,15)\sqrt{nMs\ error}$	14.51	16.81	18.27	19.35	20.18

	150	120	90	60	30	10
150						
120						
90						
60						
30						
10						

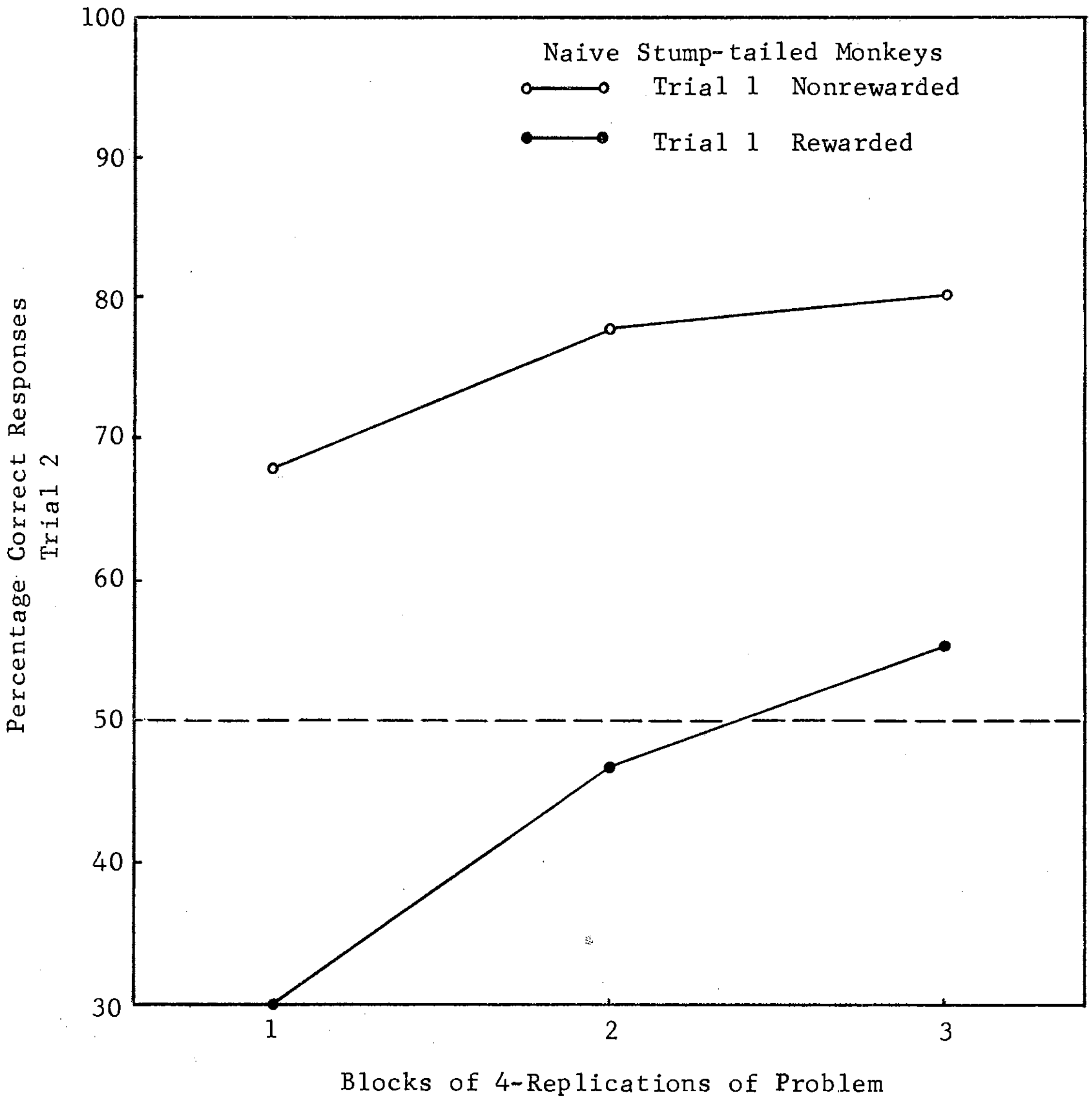

Fig. 12. Trial 2 interproblem performance following rewarded or nonrewarded single object on Trial 1 per 4-replications of each problem.

TABLE XI

ANALYSIS OF VARIANCE (TRIALS 2-7)
STUMP-TAILED MONKEYS

Source	SS	df	MS	F
CF	21476.28	1	21476.28	
Total	1156.72	287	4.03	
Subjects (S)	31.98	3	10.66	
Intertrial Interval (I)	74.66	5	14.93	7.64***
Reward Contingency (R)	124.03	1	124.03	45.20**
Trials (T)	190.45	5	38.09	17.83***
I X R	7.57	5	1.51	
I X T	62.99	25	2.52	
R X T	104.78	5	20.96	6.08**
I X R X T	40.49	25	1.62	
S X I	29.33	15	1.96	
S X R	8.23	3	2.74	
S X T	32.04	15	2.14	
S X I X R	55.08	15	2.67	
S X I X T	198.77	75	2.65	
S X R X T	51.71	15	3.45	
S X I X R X T	144.61	75	1.93	

**p = <.01
***p = <.001

were significant: Trial 1 ($F = 45.20$, $df = 1/3$, $p < .01$), intertrial interval ($F = 7.64$, $df = 5/15$, $p < .001$), Trials ($F = 17.83$, $df = 5/15$, $p < .001$), and Trial 1 X Trials ($F = 6.08$, $df = 5/15$, $p < .01$). Figs. 13 and 14 have summarized these data. Fig. 13 represents the over-all percentage of correct responses (Trials 2-7) following differential reward conditions over varying delay intervals. Significantly better performance was obtained following a nonrewarded Trial 1 condition at all intertrial delays. A marked decrease in performance resulted by increasing the delays between Trials 1 and 2. The Newman-Keuls test was used to evaluate differences in performance resulting from varying delay periods following an unrewarded first trial (see Table XII). The analysis of the delay variable revealed that performance after a 10-sec. delay was significantly superior ($p < .01$) to performance after a 30, 60, 90, 120, or 150 sec. intertrial delay. Similarly, performance after a 30 sec. intertrial interval was significantly higher than performance after a 90, 120, or 150 sec. intertrial duration. No other comparisons were statistically significant. These results suggest a decrease in discrimination performance by increasing the delay from 10 to 30 sec. Intertrial delays beyond 30 sec. produced minor reductions in discrimination performance.

The curves in Fig. 14 portray the course of intraproblem performance following the originally rewarded and nonrewarded single stimulus objects for all intertrial intervals. As this figure shows, the effect of the unrewarded first trial appears to be greatest in the beginning trials.

A comparison of Trial 1 reward contingencies on interproblem performance for all intertrial intervals is shown in Fig. 15. The superiority of performance resulting from an unrewarded initial response

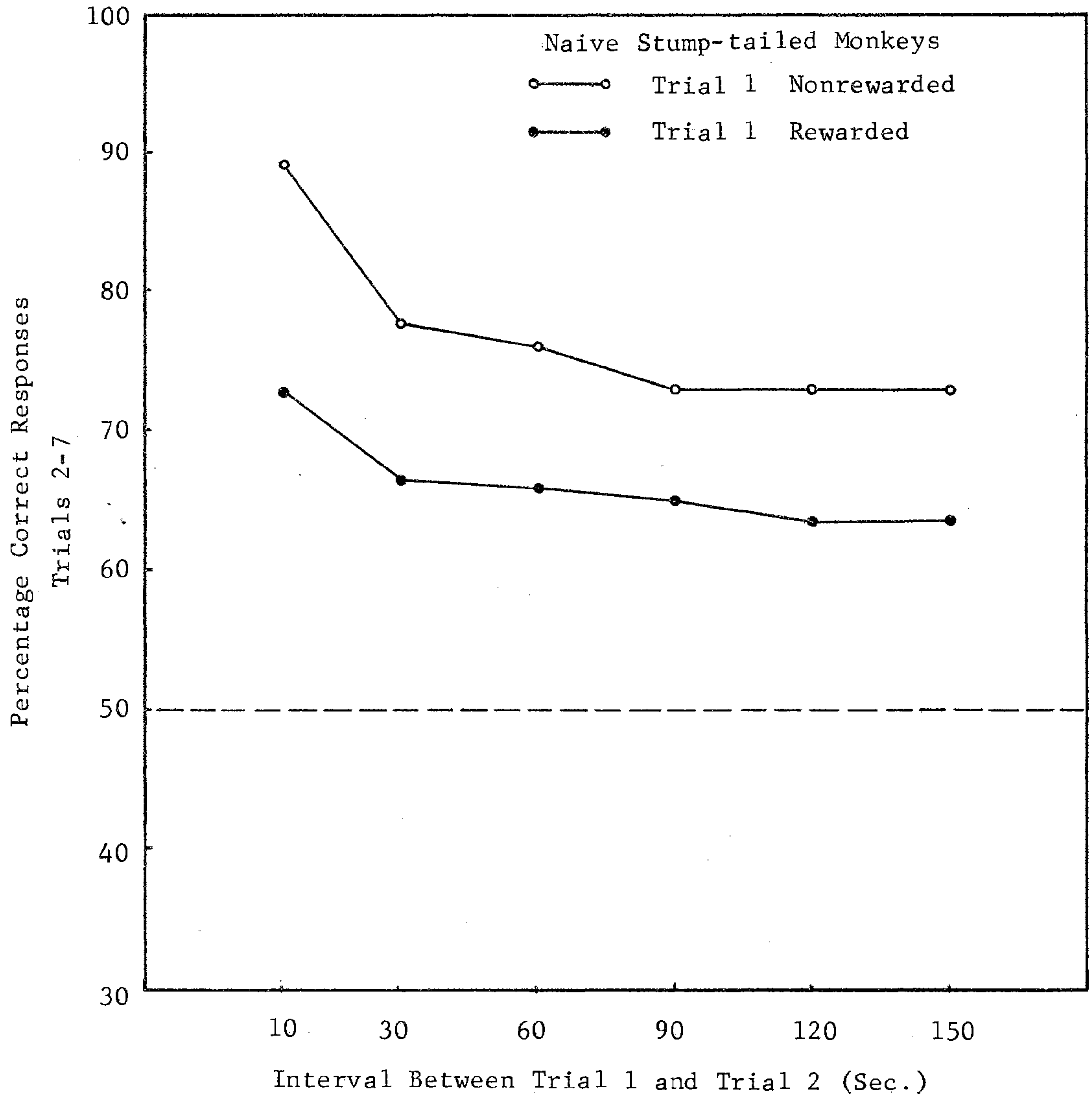

Fig. 13. Percentages of correct responses on Trials 2 through 7 involving presentation of a single rewarded or non-rewarded object on Trial 1, followed by varying intervals between Trials 1 and 2.

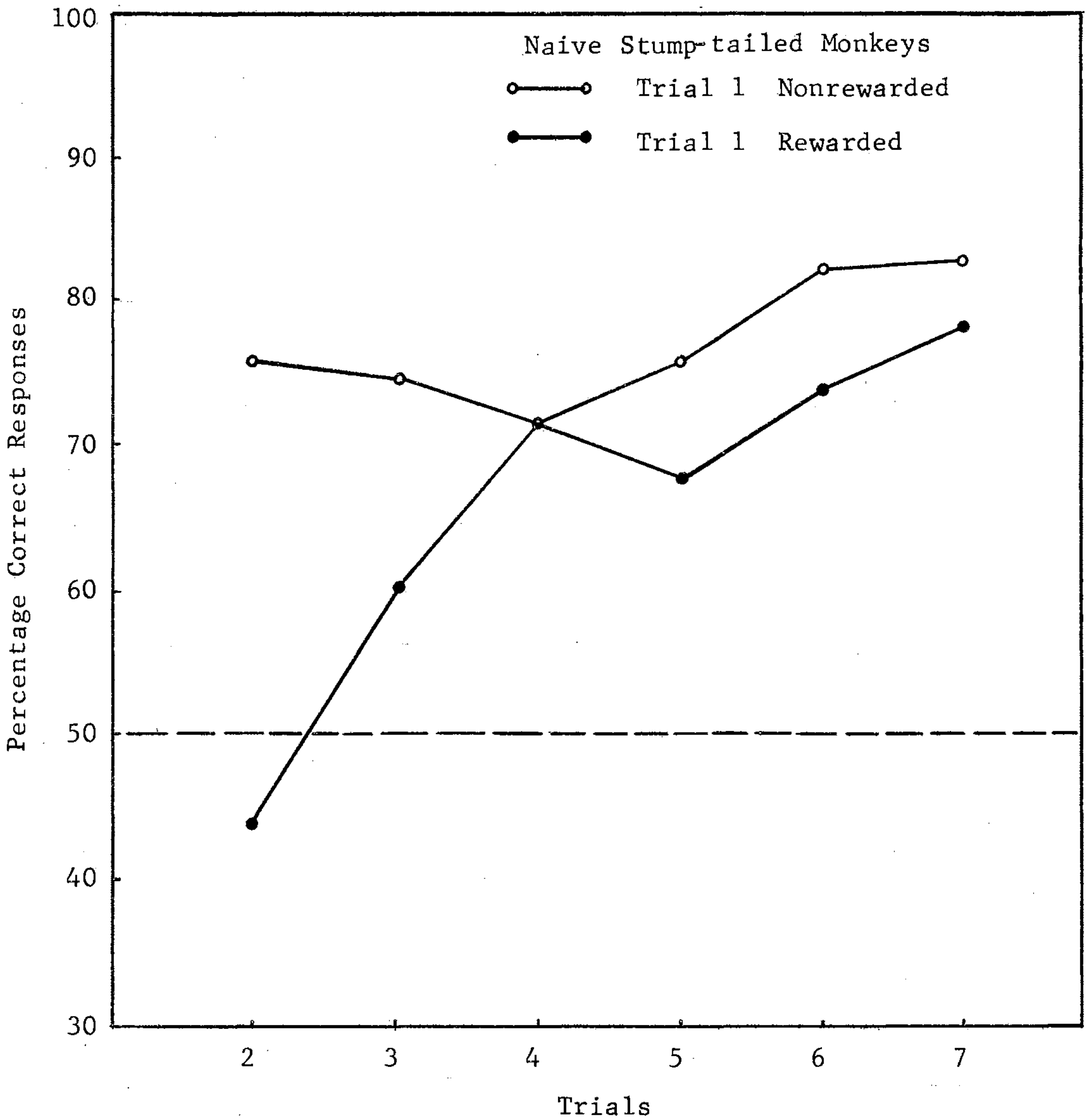

Fig. 14. Over-all intraproblem performance following rewarded or nonrewarded single objects on Trial 1.

TABLE XII

TESTS ON DIFFERENCES BETWEEN PAIRS OF TOTALS USING THE NEWMAN-KEULS PROCEDURE (TRIALS 2-7) STUMP-TAILED MONKEYS

Intertrial Interval		150	120	90	60	30	10
	Totals	212	212	212	219	226	257
150	212		0	0	7	14	45
120	212			0	7	14	45
90	212				7	14	45
60	219					7	38
30	226						31
10	259						

r =	2	3	4	5	6
q.95(r,15)	3.01	3.67	4.08	4.37	4.60
q.99(r,15)	4.17	4.83	5.25	5.56	5.80
q.95(r,15) $\sqrt{\text{nMs error}}$	8.40	10.24	11.38	12.19	12.83
q.99(r,15) $\sqrt{\text{nMs error}}$	11.63	13.48	14.65	15.51	16.18

	150	120	90	60	30	10
150					*	**
120					*	**
90					*	**
60						**
30						**
10						

*p = <.05
**p = <.01

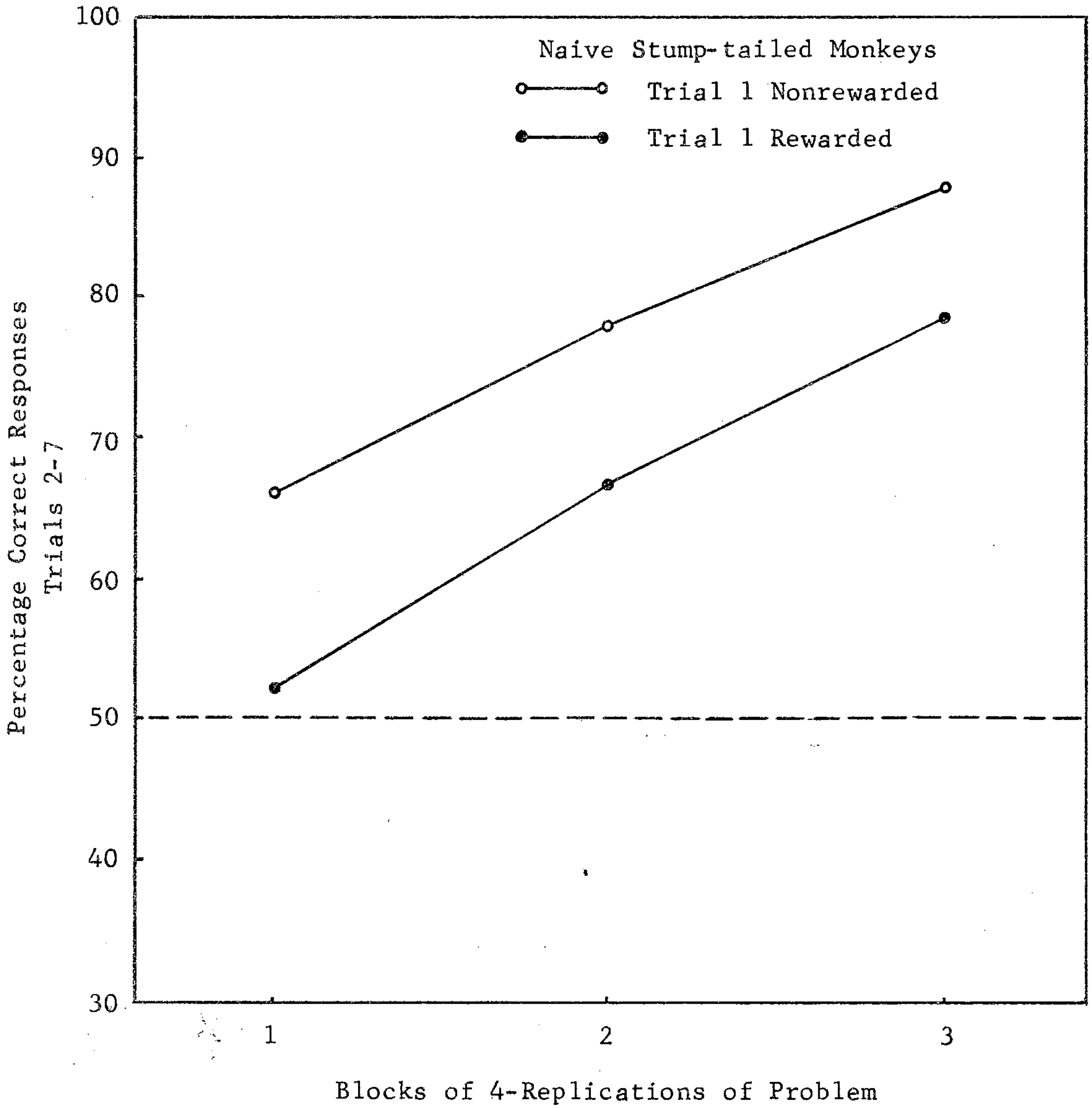

Fig. 15. Interproblem performance on Trials 2 through 7 following rewarded or nonrewarded single object on Trial 1 per 4-replications of each problem.

is quite evident. The upward slope of these curves reflects the increasing efficiency with which the problems were solved.

Summary of Results

Experiment I: Sophisticated Squirrel Monkeys

Performance on Trial 2 and Trials 2 through 7 was significantly better when the Trial 1 response was unrewarded than when it was rewarded. In general, increasing the intertrial interval from 10 sec. to 60 sec. resulted in a substantial drop in discrimination performance. Intraproblem performance indicated general improvement as a function of trials with the nonrewarded first trial resulting in superior performance. An examination of the data showed that the unrewarded first trial had its greatest effect upon the beginning series of trials. Performance over blocks of replicated problems was virtually the same.

Experiment II: Naive Rhesus Monkeys

In Exp. II, the percentage of correct Trial 2 responses was significantly greater when the initial trial was unrewarded than rewarded. Although Trial 2 correct responses gradually diminished with increased intertrial delays, the differences were not statistically significant. The data for Trials 2 through 7 showed superior performance following the unrewarded Trial 1 response. A significant decrement in performance resulted when the intertrial interval was increased from 10 sec. to 30 sec. only. Intraproblem performance revealed better performance following an unrewarded Trial 1 condition, however, the superiority of the unrewarded first trial was largely restricted to the immediately following trials. The data showed a gradual improvement in performance over blocks of replicated problems.

Experiment III: Naive Stump-tailed Monkeys

The Trial 2 performance following a nonrewarded Trial 1 response was superior to performance following a Trial 1 rewarded response. The intertrial interval factor for Trial 2 data lacked over-all statistical significance. Consistent improvement in discrimination performance was observed over blocks of replications for Trial 2. The data for Trials 2 through 7 resulted in significantly better performance following a nonrewarded Trial 1 response. Analysis of the intertrial interval variable revealed that performance dropped significantly when the delay was increased from 10 sec. to 30 sec. Beyond 30 sec. minor reductions in discrimination performance were obtained. Intraproblem performance following the initially unrewarded stimulus was better than performance following the initially rewarded stimulus object. The effect of the unrewarded first trial was greatest in the beginning trials. Interproblem performance showed gradual improvement over replicated blocks of problems.

CHAPTER IV

DISCUSSION

The experiments reported in this research were designed to test certain predictions derived from an inhibitory theory of learning and to determine whether the inhibitory process varies with test experience and different species of primates. Differences in sex and previous experience of Ss precludes a detailed comparison of the absolute values obtained in the three experiments; yet, comparison reveals that the results closely parallel each other. The results of the three experiments are consistent in demonstrating that the reward contingency of Trial 1 markedly affected Trial 2 performance. When an object is presented alone for one trial and is then paired with a new object for several trials, Ss make fewer errors if the original object is nonrewarded than if it is rewarded.

The Trial 1 X Trials interaction effect in Exps. I, II, and III indicates gradual improvement in intraproblem performance as a function of trials with the unrewarded first trial resulting in superior performance. An examination of the data, however, shows that the large and highly significant effect of the Trial 1 reward condition was limited to the beginning series of trials. Thereafter, the superiority of the unrewarded first trial was relatively small. This result was quite consistent in the sophisticated squirrel, naive rhesus, and naive stump-tailed monkeys and is in excellent agreement with the findings published by Fletcher and Cross (1964) for relatively naive monkeys. The empirical fact, therefore, seems well established that within situations like Harlow's and those described here both test-wise and naive monkeys tend to avoid the consistently nonrewarded stimulus more often than they choose the consistently rewarded stimulus. These data give added support to a theory such as Harlow's which assumes that monkeys learn predominantly which objects not to choose.

Beyond their empirical value, however, these data provide a test of the relative contribution of excitatory versus inhibitory processes. A cursory consideration of the results might lead one to conclude that these data are incompatible with theories which stress excitatory consequences of rewarded responses (for example, Spence, 1936). Analysis of the data, however, suggests that the opposite conclusion may be drawn. While the Trial 2 results of this research show that naive monkeys choose the consistently rewarded stimulus to an extent not greater than chance, the results of Moss and Harlow (1947), Harlow and Hicks (1957), Harlow (1959), Fletcher and Cross (1964), and those reported here for test-wise Ss, show above chance performance following an initial correct response. Thus, while there is some evidence that Ss choose a previously rewarded stimulus (excitatory process), the overwhelming evidence is that Ss avoid a previously unrewarded stimulus (inhibitory process). These data would appear compatible with a view that places primary emphasis on the learning of avoidance responses to the nonrewarded object yet which acknowledges the learning of approach responses to the rewarded object (for example, Warren and Kimball, 1959; D'Amato and Jagoda, 1961; Fletcher and Cross, 1964; Cross and Brown, 1965). In any event, support for an inhibition theory of learning comes from the fact that a response to a stimulus which is nonrewarded produces a tendency to avoid that stimulus and this tendency is greater than a corresponding tendency to approach, or repeat, a response to a stimulus which is rewarded.

It is not clear why monkeys do not utilize the positive single-object "information-trial" procedure. Riopelle (1955) has suggested that following a correct response, exposure of the reward acts as a distractor which interferes with learning. It might also be hypothesized that the negative single-object "information-trial" conveyed more information than the positive "information-trial." Exposure to the negative stimulus informs S that this stimulus is unrewarded, and when it is later paired with a new stimulus it will be unrewarded again. Exposure to the positive stimulus informs S that this stimulus is rewarded, and when it is later paired with a new stimulus it will be rewarded again. In the latter situation, however, there is nothing to indicate to S why the new stimulus may not also be rewarded. These propositions offer an explanation at least for Trial 2 performance following a single rewarded or nonrewarded trial.

D'Amato and Jagoda (1961) proposed that in terms of survival value, it would be more important for primitive organisms to know what to avoid rather than what to approach, since the organism comes equipped with the appropriate approach responses. Whatever the explanation, discrimination performance following a nonrewarded first trial is evidently different from performance following a rewarded first trial in both naive and sophisticated monkeys. No adequate explanation of the poorer performance following the positive first trial can be proposed here and this will have to wait on future research.

Additional evidence for a predominantly inhibition theory of discrimination learning has been presented by data which indicates that the relatively stronger inhibitory effects of nonrewarded trials dissipates as a function of time. In Exps. I, II, and III, temporal delays generally produced comparable decrements in performance under conditions of Trial 1 reward and nonreward at all intertrial intervals. Performance curves for all three experiments clearly demonstrate that the inhibitory tendency associated with nonreward dissipates by increasing the duration of the intertrial interval. Sophisticated squirrel monkeys (Exp. I) show progressive decline in performance by increasing the intertrial interval from 10 sec. to 60 sec. Increasing the intervals beyond 60 sec. appears to produce minimal effects upon discrimination performance.

In general, temporal delays in Exp. II and Exp. III produced comparable deficits in performance as a function of delay periods. Both naive rhesus and naive stump-tailed monkeys show a progressive decline in performance when the duration of the interval is increased from 10 sec. to 30 sec. only. Discrimination performance remained relatively constant at longer delay intervals. The performance curves (Figs. 6, 8, 11, 13) plotted independently for Trial 1 reward contingency and delay intervals are not different in form for the naive rhesus and naive stump-tailed monkeys. It can be observed that the inhibitory tendency appears to dissipate more rapidly during the first 60 sec. for squirrel monkeys than for rhesus and stump-tailed Ss. This difference between the species may be related to the results of Miles (1957) who showed that the relatively primitive squirrel monkey develops discrimination learning-sets much more slowly than the rhesus monkey.

Assuming that inhibition dissipates with time, these results suggest that incorrect response tendencies after a short intertrial interval remain inhibited and thus increase the probability of a correct Trial 2 response. On the other hand, during the relatively long intertrial interval the inhibition associated with an incorrect Trial 1 response dissipates to an extent that the probability of a correct response is reduced to chance levels.

In the three experiments there appear to be some differences in interproblem performance over replicated problems. Sophisticated squirrel monkeys showed negligible improvement over blocks of problems. This finding suggests that these monkeys had achieved a high degree of performance in the early series of discrimination problems. Interproblem performance for the naive rhesus and naive stump-tailed Ss revealed some over-all improvement over blocks of problems.

Considered in their entirety, the data of these three experiments give strong additional support regarding differential effects of Trial 1 reward contingency. Further, these data indicate that monkeys learn predominantly which objects not to choose. Evidence for an inhibition theory of learning has been provided by the spontaneous rate of decay in time of the inhibitory tendency associated with the incorrect response. The inhibitory process has been shown to operate in both naive and test-experienced Ss and has been extended to include stump-tailed and squirrel monkeys. The over-all course of dissipation was more or less negatively accelerated over the range of intertrial intervals investigated.

Suggestions for Future Research

The present results raise a number of questions regarding the inhibitory process underlying two-object discrimination learning. A first line of investigation suggests the use of certain drugs in studying the inhibitory process in monkeys. Since poorer learning performance has been amply shown to result from the administration of such drugs as chlorpromazine and pentobarbital, it would be of interest to determine the rate of dissipation of inhibition in drugged Ss.

It seems likely that mammals at the primate level, both naive and test-experienced, learn what not to approach, that is, learn to avoid the nonrewarded stimulus object. D'Amato and Jagoda (1961) have indicated that in terms of survival value, it would be more important for primitive organisms to know what to avoid than to know what to approach. Monkeys quite naturally reach toward objects where food might be located; hungry rats quite naturally run into alleys where food might be located. Interpreted in this way, approach to the rewarded stimulus needs little learning since it is present at the start. The primary requirement of the animal appears to be to learn to inhibit his approach responses to the incorrect stimulus.

Although the present study and its implications are most relevant to animal discrimination situations, it would be of interest to replicate the present research employing human subjects, for example, children. It is possible that support for the role of avoidance learning in discrimination performance may not be obtained. For the more versatile human, it is possible that dependence upon the inhibitory process may not be so great and that learning of approach responses is a more adaptable form of behavior.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this research was to examine the decay of inhibition in time. A review of an inhibition conception of discrimination learning and research pertinent to this point of view led to the development of the following specific aims: (1) examine discrimination performance as a function of a rewarded and nonrewarded single object on Trial 1, (2) test the influence of various intertrial intervals between the presentation of Trial 1 and Trial 2, (3) ascertain whether the temporal decay of inhibition is altered by different amounts of past test-experience, (4) determine if different species of monkeys differ significantly in the rate with which the inhibitory tendency associated with an incorrect response dissipates with time.

To investigate these aims, three experiments were conducted involving a differential Trial 1 reward contingency (reward vs. non-reward) and an intertrial interval of 10, 30, 60, 90, 120, or 150 sec. between Trial 1 and Trial 2. Exp. I utilized 6 sophisticated squirrel monkeys, Exp. II employed 4 naive rhesus monkeys, and Exp. III used 4 naive stump-tailed monkeys. The following results were obtained:

1. In all three experiments the data demonstrated that the unrewarded Trial 1 resulted in markedly better Trial 2 performance than did the rewarded Trial 1 condition. Although the effect was manifested in subsequent trials, it was most pronounced in Trial 2.

Intraproblem performance following the unrewarded Trial 1 was small in comparison to the improvement following the rewarded Trial 1. This result was consistent for the three species of monkeys.

2. The nonrewarded first trial produced significantly more over-all correct responses at all intertrial intervals. Performance curves for all three experiments demonstrated that the inhibitory tendency associated with nonreward generally dissipated by increasing the duration of the intertrial interval.

3. The over-all data for squirrel monkeys showed a rapid drop in performance by increasing the intertrial interval from 10 sec. to 60 sec. Intervals beyond 60 sec. resulted in smaller deficits in discrimination performance.

4. Although naive rhesus and naive stump-tailed monkeys showed a progressive decline on Trial 2 performance by increasing the delays from 10 sec. to 150 sec., the differences between the delays were not significant. Performance for Trials 2-7 revealed a significant drop in performance by increasing the intervals from 10 sec. to 30 sec. Performance remained relatively constant at longer intertrial intervals.

5. Naive rhesus and naive stump-tailed monkeys showed more inter-problem discrimination learning over blocks of replicated problems than did sophisticated squirrel monkeys.

6. The results were interpreted as supporting an inhibition point of view of discrimination learning.

BIBLIOGRAPHY

Behar, I. Analysis of object-alternation learning in rhesus monkeys. J. comp. physiol. Psychol., 1961, 54, 539-542.

Behar, I. Learned avoidance of nonreward. Psychol. Rep., 1961, 9, 43-52.

Behar, I. Evaluation of the significance of positive and negative cue in discrimination learning. J. comp. physiol. Psychol., 1962, 55, 502-504.

Cross, H. A. & Brown, L. T. Discrimination reversal learning in squirrel monkeys as a function of acquisition trials. J. comp. physiol. Psychol., 1965, in press.

Cross, H. A., Fickling, R. M., Carpenter, J. B., & Brown, L. T. Discrimination reversal performance in squirrel monkeys as a function of prereversal experience and overlearning. Psychon. Sci., 1964, 1, 353-354.

D'Amato, M. R. & Jagoda, H. Analysis of the role of overlearning in discrimination reversal. J. exp. Psychol., 1961, 61, 45-50.

Dennis, W. Spontaneous alternation in rats as an indicator of the persistence of stimulus effects. J. comp. physiol. Psychol., 1939, 28, 305-312.

Fletcher, H. J. & Cross, H. A. Effects of Trial 1 reward contingency, intertrial interval, and experience on intraproblem discrimination performance of monkeys. J. comp. physiol. Psychol., 57, 318-320.

Harlow, H. F. The formation of learning sets. Psychol. Rev., 1949, 56, 51-65.

Harlow, H. F. Analysis of discrimination learning by monkeys. J. exp. Psychol., 1950, 40, 26-39.

Harlow, H. F. & Hicks, L. H. Discrimination learning theory: uniprocess vs. duoprocess. Psychol. Rev., 1957, 64, 104-109.

Harlow, H. F. Learning set and error factor theory. In S. Koch (Ed.), Psychology: a study of a science. Vol. 2 New York: McGraw-Hill, 1959, 492-537.

Heathers, G. L. The avoidance of repetition of a maze reaction in the rat as a function of the interval between trials. *J. Psychol.*, 1940, *10*, 359-380.

Hull, C. L. *Principles of behavior*. New York: D. Appleton-Century, 1943.

Leary, R. W. The rewarded, the unrewarded, the chosen and the unchosen. *Psychol. Rep.*, 1956, *2*, 91-97.

Lloyd, J. S. & Carlson, N. J. An investigation of the uniprocess theory of discrimination learning in young monkeys. Paper read at the annual meeting of the Midwestern Psychological Association, Chicago, May, 1962.

Miles, R. C. Learning set formation in the squirrel monkey. *J. comp. physiol. Psychol.*, 1957, *50*, 356-357.

Moss, E. & Harlow, H. F. The role of reward in discrimination learning in monkeys. *J. comp. physiol. Psychol.*, 1947, *40*, 333-342.

Riley, D. A. & Shapiro, A. M. Alternation behavior as a function of effortfulness of task and distribution of trials. *J. comp. physiol. Psychol.*, 1952, *45*, 468-475.

Riopelle, A. J. Transfer suppression and learning sets. *J. comp. physiol. Psychol.*, 1953, *46*, 108-114.

Riopelle, A. J. Rewards, preferences, and learning sets. *Psychol. Rep.*, 1955, *1*, 167-173.

Spence, K. W. The nature of discrimination learning in animals. *Psychol. Rev.*, 1936, *43*, 427-449.

Warren, J. M. & Baron, A. The formation of learning sets by cats. *J. comp. physiol. Psychol.*, 1956, *49*, 227-231.

Warren, J. M. & Kimball, H. Transfer relations in discrimination learning by cats. *J. comp. physiol. Psychol.*, 1959, 52, 336-338.

Weitz, J. & Wakeman, M. L. "Spontaneous" alternation and the conditioned response. *J. comp. physiol. Psychol.*, 1941, *32*, 551-562.

Zeaman, D. & House, B. J. The growth and decay of reactive inhibition as measured by alternation behavior. *J. exp. Psychol.*, 1951, *41*, 177-186.

VITA

William N. Boyer

Candidate for the Degree of

Doctor of Philosophy

Thesis: DISCRIMINATION PERFORMANCE IN THREE SPECIES OF MONKEYS AS A FUNCTION OF TRIAL 1 REWARD CONTINGENCY, INTERTRIAL INTERVAL, AND PRIOR TEST EXPERIENCE

Major Field: Psychology

Biographical:

Personal Data: Born in Cowan, Manitoba, December 10, 1934.

Education: Attended Carleton University, Ottawa, Ontario and received a B. A. in 1958, with a major in psychology; received a M. A. in 1960 from the University of Toronto with a major in psychology; completed requirements for the Doctor of Philosophy degree, Oklahoma State University in August, 1965.

Professional Experience: Counseling Psychologist at the Workmen's Compensation Board Hospital and Rehabilitation Center, Toronto, Ontario from 1960 to 1961; Project Assistant at the Department of Psychology, Primate Laboratory, University of Wisconsin, during summer of 1963; Project Assistant at the University of Wisconsin, Regional Primate Research Center during summer of 1964; Graduate Teaching Assistant from 1962 to 1965 at the Oklahoma State University.